THE LINEAR TABLES DESCRIBED, AND THEIR UTILITY VERIFIED;

WITH

PRECEPTS AND EXAMPLES

FOR

SHORTENING CALCULATIONS

AND

PRESERVING ACCURACY,

IN THE

LUNAR METHOD

OF FINDING

LONGITUDE

AT SEA.

By SAMUEL DUNN, K
Teacher of the Mathematical Sciences.

LONDON:
Printed for the Author, at No. 1, Boar's-head Court, Fleet-street,
MDCCLXXXIII.

PREFATORY INTRODUCTION.

THIS Work contains two Methods of Computing the Longitude at Sea, having the Obſerved Diſtance of Sun and Moon or Moon and Star, the Obſerved Altitude of the Moon, and the Obſerved Altitude of the Sun or Star.

In the firſt of theſe Methods, the Effect of Refraction and Parallax is found, by the Application of a New Set of Linear Tables together with the Logarithms of Numbers, Sines, Tangents and Secants. In the ſecond of theſe Methods, the Effect of Refraction and Parallax, is found, by working for the Angles at the Sun and Moon, and then the Effect whether it is additive to or ſubductive from the Obſerved Diſtance, to get the true Diſtance of Centres.

In the firſt of theſe Methods, the Time at Greenwich is found in Hours, Minutes and Seconds; likewiſe, the Time at the Ship is found in Hours, Minutes and Seconds; and this compared with the Time at Greenwich gives the Longitude from Greenwich in Time, which is to be turned into Degrees and Minutes. In the ſecond of theſe Methods, the Time at Greenwich is found in Degrees and Minutes; likewiſe, the Time at the Ship is found in Degrees and Minutes, and this compared with the Time at Greenwich gives the Longitude.

When the true Diſtance of Centres is found, by either of the Methods for that purpoſe; then, either of the Methods of finding the Times at Greenwich and at the Ship may be uſed, as it may be thought moſt convenient; and if a Watch be uſed for ſhewing either the Time at the Ship, or the Meridian for which it was ſet; it may be applied to the Time at Greenwich, and the Sum or Difference in the uſual Manner will be the Longitude.

The firſt thing treated of in this Work, is the Doctrine of Refraction, in which it is ſhewn how to determine by Inſpection, what the Refraction is at any Altitude, ſuppoſing the Refraction at the Horizon leſs than it is in Winter in the Northern Part of the Temperate Zone; this is of no ſmall conſequence in the Lunar Method of finding the Longitude at Sea; it is likewiſe of uſe in determining the Latitude.

 Then

Then follows a Table ſhewing the Increaſe of the Moon's Semidiameter for Altitude, according to her reſpective Diſtances from the Earth, which are known from her Semidiameter and from her Horizontal Parallax; for, when either of theſe is ſmall, the Diſtance is great, and *vice verſa.*

Next it is ſhewn how to find the Parallax in Altitude, either to the greateſt Exactneſs by Calculation, or to the neareſt Half-minute by a Table, or to a few Seconds of a Degree by Inſpection, from a new Table for that purpoſe, the Conſtruction of which has never before appeared.

In turning Time into Degrees and Minutes, it frequently happens that the Seconds of Time fall between the Minutes of Degrees, and thereby confound the Learner, this Difficulty is here removed by extending that part of the Table to Half-minutes of a Degree; and, as Longitude cannot properly exceed One Hundred and Eighty Degrees, either Eaſting or Weſting, the remaining part of the Table is carried to that Number; there it ſtops, and what is to be done in the different Caſes, is ſhewn by Examples.

The Dip of Horizon is another Subject of no ſmall conſequence in the Lunar Method of finding the Longitude at Sea; and the various allowances that have been made by different Writers, for this moſt neceſſary correction, make it indiſputable, that many of them muſt have been erroneous. I have computed this Table from the moſt authentic Data, and applied it in a New manner to an intereſting Subject; namely, the finding of Diſtances at Sea.

The Linear Tables deſcribed in this work, are upon a Plan which is entirely new, and which admits of Extenſion to a great variety of other Subjects, wherein Proportional Parts have been inſuperable Hinderances to Calculators. It is a peculiar Circumſtance attending the Conſtruction of theſe Tables; that when Numbers are to be taken out by them, they require no Thought in the Calculator concerning Proportional Parts; which all other kinds of Tables require. In uſing other Tables, he muſt be ready at the Rule of Three Direct, with one, two or more Figures, ſometimes ſeveral Times in a ſingle Proceſs, and frequently be perplexed in thinking whether their Reſults are to be added or ſubtracted.

The Linear Table I. is an Inſtance of the Utility of this Invention; for, if the ſame Table were expreſſed in a numerical manner, it would fill at leaſt Twenty times the Space, without being of more real ſervice in finding the Longitude. At the ſame time this Table ſhews by Inſpection, what Data require attention to the ſmaller Parts of Degrees and what do not; this is not contained in any other Method whatever. If it be remarked that ſometimes Index Three inſtead of Two may ariſe in uſing this Table, and that then four Figures for Seconds will come out for Number A; it may be obſerved, that this can happen at no other time but when one of the

Altitudes

Altitudes is very ſmall, the other very great, and the Diſtance very ſmall; and in ſuch Caſes, the Errors ariſing by the application of any other Table of this kind, adapted to one ſuppoſed Refraction at the Horizon, will be four times as great, as the Errors for want of the additional number in this Table.

A ſimilar Remark may be made, on the application of Tables computed upon a ſuppoſed Equality of Refraction at the Horizon, at all Times and Places, with a certain Number of Minutes for the Horizontal Parallax. In the Formation of ſuch Tables, the Effect of Refraction diminiſhes faſt from the Horizon upward, but the Effect of Parallax diminiſhes ſlowly as the Coſine of the Altitude; and therefore, although Table I. is ſufficient for the Correction of Refraction, it is by no means ſufficient for the Correction of Parallax, becauſe the latter will require four figures at leaſt beſide Index.

When a Table is formed for ſhewing the Effects of Refraction and Parallax at once, the Refraction near the Horizon in ſuch a Table is ſuited to ſome particular place of the Earth, and the like is not to be expected at all other places; this is a part of the Foundation on which the Table ſtands, and when Pneumatic and Hydroſtatic Inſtruments of a delicate kind are introduced to point out Corrections, it becomes a queſtion how far thoſe Subſtitutes may be depended on for anſwering the Purpoſe?

In the uſe of ſuch a Table, formed for whole Degrees of Diſtance, and whole Degrees of Altitude for each Luminary, with a fixed Horizontal Parallax of the Moon; there will be at leaſt four Corrections, generally occurring; namely, one for the intermediate Minutes of Diſtance, another for the Altitude of each Luminary, and a fourth for the Variation of Horizontal Parallax of the Moon, according to its difference from that which is ſuppoſed in the Table.

When theſe Corrections are making, ſome of them will be additive, others ſubductive; ſome great, others ſmall; all which tends to embarras the Computor, nor can he with ſafety reject any of them, and inſtead thereof take the Tabular Reſult of whole Degrees; becauſe the Corrections here are chiefly for the large Effect of Parallax (and not the ſmall Effect of Refraction) which may amount to Nine Minutes of a Degree at Ten Degrees Altitude; Eight Minutes at Forty-two Degrees Altitude; and is ſo great as Two Minutes at Eighty Degrees Altitude. This appears at Sight by Linear Table XIV. It alſo appears that, with ſmall Diſtances and ſmall Altitudes of the Moon, the Error by uſing whole Degrees in ſuch a Table, with its included Parallax, will frequently amount to more than Two Minutes of a Degree. It is therefore reaſonable to conclude, that when ſuch a Table is uſed without proportioning for the intermediate Minutes, under all the four forementioned circumſtances, the Errors may (for want of them) amount to Ten Minutes

of

of a Degree, which at the Equinoctial is an Error of Three Hundred Nautical Miles.

Whilst the Method was practised, of finding Proportional Parts for the intermediate Numbers of Mr. Lyons's Table I. but a few out of a considerable Number of Persons, could understand it; this induced me to substitute the nearest whole Degrees, and the Twenty two Examples in this work, prove that no great Error in taking the Longitude at Sea, can have happened on that Account. The Table shewing the effects of Refraction and Parallax, requiring more and greater Corrections to be made, must therefore be with more and greater Difficulties accurately applied.

The Reductions into Seconds amongst the Linear Tables, will save the Computor both time and trouble, if he computes by the Sun and Moon's Angles; for in that Method, the Parallax in Altitude is had by Inspection from Table XIV. in Seconds, and the Refraction in Altitude is had in Seconds from Table VII. and with these, the Logarithms are taken out to get M. It is likewise ready for turning either the three hourly Differences, or the Difference between the first Hours and E, into Seconds by Inspection, in using the Formula for Longitude which is in this work.

The true Distance of Centres being found, the Times at Greenwich and at the Ship are found by the Instructions for that Purpose, and then the Longitude of the Ship.

Having enumerated the principal Steps that are to be taken in this Method, it seems not improper to deliver the first Principles upon which the Longitude at Sea depends, whether it be known from an Account of the Courses and Distances sailed, or discovered from actual Observations.

Geographers frequently name the whole Great Circle passing round the Earth from North to South, the Meridian of a place; but it seems more accurate to name it that Great Semi-circle passing through the place from Pole to Pole.

The Meridian of London passeth through St. Paul's Cathedral London. The Meridian of Greenwich passeth through the Royal Observatory at Greenwich.

The Meridian of London being continued northward, leaves England near Flamborough-head in Yorkshire. It then crosseth the Northern Seas, and being continued 38°. 29'. from London, comes to the Earth's North Pole.

This Meridian being continued southward, leaves England near Brighthelmstone in Sussex. It then crosseth the British Channel and enters France near the Town of Auberville. By crossing the Pyrenean Mountains it enters Spain, and leaves it a little westward of the Entrance of Ebro River. It then passeth over the Mediterranean Sea, enters Africa near Oran and leaves it about 60 Miles eastward from Cape Three Points. It then enters the Ethiopean Sea and at the

the distance of 51°. 31'. from London comes to the Equinoctial Line. Here the Longitude from London begins to be reckoned, in the Arch of a Great Circle which is every where equally distant from the Poles, Eastward to 180°. for East Longitude, and westward for West Longitude to 180°.

Continuing this Meridian 90° southward it comes to the South Pole of the Earth. This Extent from the North to the South Pole compleats the first Semi-circle of the Meridian of London, at all places of which, it is Noon Day at the same Instant.

Continue the first Semi-circle through the Earth's Poles to compleat the opposite or second Semi-circle, and it will pass through the Great South Sea, 180° at the Equinoctial distant from the first Semi-circle. At all places in this latter, it will be Midnight when it is Noon-day at the former. This compleats the Great Circle commonly called the Meridian of London, dividing the East Longitude from the West.

The nearest Distance from St. Paul's London to the Meridian of Greenwich is four Miles wanting a sixteenth of a Mile. The nearest Distance of those Meridians at the Equinoctial is six nautical Miles and a third. At the Equinoctial, a Degree of Distance is a Degree of Longitude, and a Mile of Distance is a Minute of Longitude.

Almost all Europe, Asia and Africa, are in East Longitude from London and Greenwich. North and South America are in West Longitude from Greenwich.

The Seas northward of Europe and Asia, the Baltic and Caspian Seas, almost all the Mediterranean, part of the Ethiopic Ocean, the Indian Ocean and part of the Pacific Ocean or Great South Sea, these are in East Longitude both from London and from Greenwich. The Atlantic or Western Ocean, and a great part of the Pacific Ocean, are in West Longitude from London and Greenwich.

Of all the things that can be either Objects perceivable by our Senses or Subjects for our Minds to contemplate on, there is scarce any thing more difficult to be defined, than what is commonly called Time.

The Idea which we commonly have of this Existence ariseth from a Comparison of one Moment or Instant with another, and according to the Length of Duration which we can perceive to be between them, the Quantity or Interval of Time between those Bounds is estimated.

According to these Principles, one might at first conclude that, when the Limits of two Intervals of Duration are at the same Distance from each other, the intermediate Times will be equal, or what amounts to the same thing, that Time flows uniformly; but this is contrary to the Principles whereby it is regulated.

The apparent Motions of the Celestial Bodies, and particularly of the Sun; these are the only Measures whereby the Quantities of

Time

Time are estimated, and they are sometimes nearly uniform, but most commonly to all appearance either accelerated or retarded.

When an Attempt of any kind is made for measuring the Quantities of Duration by Clocks, Watches or other Mechanical Contrivances, such are clogged with many and great Difficulties. 1st. They have no perfect Standard whereby they may be compared. 2d. They are liable to various Degrees of Imperfection; the quantities of which (from them alone) can never be assigned. These Reasons, without mentioning any other, are sufficient to shew that they can be but Imitators of those accurate Measures whereby either equal or unequal Time is measured.

When the Centre of the Sun is apparently on the Meridian of Greenwich, the Solar Day begins there, and ends when that Centre is next apparently on that Meridian, which is the following Day at Noon.

Every Solar Day is either a little longer or shorter, than that going before or following it; this small Difference is called the Difference of the Equation of Time from one Day to another.

A Solar Day contains 24 Hours which are nearly equal to each other; each Hour is divided and subdivided into Minutes and Seconds of Time.

The greatest Difference between the Length of one Solar Day and another, is about the 20th of December, then it is Half a Minute of Time. Toward the Middle of February and May, the End of July and Beginning of November, this Difference amounts to but a few Seconds of Time.

The Circumference of the Equinoctial is 360° answering to 24 Hours, therefore Half a Minute of Time answers to Seven Minutes (or Miles) and half of a Degree of the Equinoctial. This is the greatest Error that can arise from the Extremes, by turning Solar Time into Degrees of the Equinoctial. In other Cases it will be less, and frequently so small as to be almost insensible. This is the Time which is used in the Lunar Method of finding Longitude at Sea.

By a Comparison of the true Distances of Centres, as deduced from the twenty-two Examples in this Work, it appears that the Methods of correcting Refraction and Parallax, both by the Linear Tables and by the Sun and Moon's Angles, are as accurate as other Methods that have been published; and that no censure can happen to me, for having substituted Mr. Lyons's whole Degrees, to take off the Computation of Proportional Parts; but when it is considered with what Ease they are practised and what Improvements they are capable of, they are both of the first Class for Truth and Utility.

Fleet-Street,
May 16, 1783.

S. DUNN.

THE LINEAR TABLES DESCRIBED, &c.

SECTION I.

Of Refraction in Altitude, and the Tables which are formed for shewing its Quantity.

REFRACTION in Altitude is either the number of Seconds, or Minutes and Seconds of a degree, which the Sun, Moon, Stars, or any other celestial Bodies appear more elevated above the Horizon of a Place, than they really are; and a Table of Refraction, is for shewing those Seconds or Minutes and Seconds of a Degree, from the Horizon to the Zenith. At the Horizon it is greatest, and at the Zenith it is nothing. In the North Temperate Zone, it hath been found near the Horizon, at one and the same place, Two Minutes of a degree greater in Winter than in Summer; from which the Medium has been taken to be Thirty Three Minutes. At the Horizon near the Equinoctial, it has been found Twenty Seven Minutes; and in the South Temperate Zone, it has been found greater than at the Equinoctial.

In the annexed Table, the Refraction at the Horizon is supposed 34′. 27″ and against the different Altitudes are the correspondent Refractions in Altitude, supposing that the foresaid Refraction is at the Horizon. If the Refraction at the Horizon is less than 34′.

27″; go downward till you find it nearly, in the Column of Refraction, and observing how many Minutes of Altitude you have then advanced, go downward as many Minutes from any other Altitude, and against it is the Refraction in Altitude for that Refraction at the Horizon.

In the Linear Tables, Article VII. is a Table of Refraction as it has been observed near London. In that Table, the Degrees and Parts of a Degree of Altitude run from left to right, and opposite to them are the Seconds of Refraction, with the Differences of Refraction in Seconds for each Degree. This Method of shewing the Refraction, is expeditious and certain to a Second of a Degree, and therefore well adapted for computation, where those Seconds are to be taken and subtracted from the Seconds of Parallax in Altitude.

From these Principles the two following Rules may be drawn and applied for finding the Refraction for any Altitude, and any Refraction at the Horizon less than that in a Table.

1st, When the Refraction at the Horizon is equal to that in a Table.

Subtract the correspondent Refraction in the Table, from the given Altitude, and the Remainder is that Altitude cleared from Refraction.

2d, When the Refraction at the Horizon is less than that in a Table.

In the Column of Refraction, go downward to the given Refraction at the Horizon and note the Minutes of Altitude advanced. Then, advance as many Minutes in Altitude, from the Altitude given, and against it is the Refraction required.

EXAMPLE I.

Refrac. at Hor.	0°.	34′.	27″
Altitude observed	1.	0.	0
Refrac. for Alt.	0.	24.	32
Altitude cleared	0.	35.	28

This agrees with Sir Isaac Newton's Tables.

EXAMPLE II.

Rerfac. at Hor.	0°.	27′	0″.
Altitude observed	2.	0.	0
Refrac. for Alt.	0.	15.	30
Altitude cleared	1.	44.	30

This agrees nearly with Observations made near the Equinoctial.

EXAMPLE III.

Refrac. at Hor.	0°.	31′	0″
Altitude observed	3.	0.	0
Refrac. for Alt.	0.	13.	26
Altitude cleared	2.	46.	34

This agrees nearly with a Medium between Sir Isaac Newton and Dr. Brook Taylor.

EXAMPLE IV.

Refrac. at Hor.	0°.	32′.	0″
Altitude observed	4.	0.	0
Refrac. for Altitude	0.	11.	16
Altitude cleared	3.	48.	44

This agrees nearly with a medium between Sir Isaac Newton and Dr. Bradley.

EXAMPLE V.

Refrac. at Hor.	0°.	33′.	0″
Altitude observed	5.	0.	0
Refrac. for Alt.	0.	9.	28
Altitude cleared	4.	50.	32

This agrees nearly with a medium between Sir Isaac Newton and Dr. Bradley

EXAMPLE VI.

Refrac. at Hor.	0°.	33′	30″
Altitude observed	6.	0.	0
Refrac. for Alt.	0.	8.	10
Altitude cleared	5.	51.	50

This agrees nearly with a medium between Dr. Halley, Dr. Bradley, and M. de la Caille.

Of

A Table of REFRACTION in ALTITUDE, by S. Dunn, Teacher of Mathematics LONDON.

Alt.ᵈ	Refrac.ⁿ	Alt.ᵈ	Refrac.ⁿ	Alt.ᵈ	Refrac.ⁿ	Alt.ᵈ	Refrac.ⁿ	Alt.ᵈ	Refrac.ⁿ	Alt.ᵈ	Refrac.ⁿ	Alt.ᵈ	Refrac.ⁿ	Alt.ᵈ	Refrac.ⁿ
° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″
.0	34.27	.30	28.57	1.0	24.32	3.0	14.28	5.0	9.40	8.	6.24	37.	1.12	66.	.25
.1	34.15	.31	28.47	.4	24.3	.4	14.12	.6	9.28	9.	5.43	38.	1.9	67.	.23
.2	34.3	.32	28.37	.8	23.35	.8	13.56	.12	9.16	10.	5.10	39.	1.7	68.	.22
.3	33.51	.33	28.28	.12	23.8	.12	13.44	.18	9.4	11.	4.43	40.	1.5	69.	.21
.4	33.39	.34	28.18	.16	22.42	.16	13.32	.24	8.56	12.	4.19	41.	1.2	70.	.20
.5	33.27	.35	28.9	.20	22.17	.20	13.20	.30	8.51	13.	3.58	42.	1.0	71.	.19
.6	33.15	.36	27.59	.24	21.52	.24	13.8	.36	8.45	14.	3.40	43.	.58	72.	.18
.7	33.3	.37	27.49	.28	21.28	.28	12.56	.42	8.39	15.	3.24	44.	.56	73.	.17
.8	32.51	.38	27.40	.32	21.4	.32	12.44	.48	8.33	16.	3.9	45.	.54	74.	.16
.9	32.40	.39	27.31	.36	20.40	.36	12.32	.54	8.27	17.	2.56	46.	.52	75.	.15
.10	32.29	.40	27.23	.40	20.16	.40	12.20	6.0	8.21	18.	2.45	47.	.51	76.	.14
.11	32.17	.41	27.13	.44	19.52	.44	12.12	.6	8.10	19.	2.35	48.	.49	77.	.13
.12	32.6	.42	27.4	.48	19.31	.48	12.4	.12	8.4	20.	2.26	49.	.47	78.	.12
.13	31.55	.43	26.55	.52	19.11	.52	11.56	.18	7.58	21.	2.18	50.	.46	79.	.11
.14	31.44	.44	26.46	.56	18.51	.56	11.48	.24	7.52	22.	2.11	51.	.44	80.	.10
.15	31.33	.45	26.37	2.0	18.31	4.0	11.40	.30	7.46	23.	2.5	52.	.42	81.	.9
.16	31.22	.46	26.28	.4	18.15	.4	11.32	.36	7.39	24.	2.0	53.	.41	82.	.8
.17	31.11	.47	26.19	.8	17.56	.8	11.24	.42	7.33	25.	1.55	54.	.39	83.	.7
.18	31.0	.48	26.10	.12	17.36	.12	11.16	.48	7.27	26.	1.50	55.	.38	84.	.6
.19	30.49	.49	26.2	.16	17.16	.16	11.8	.54	7.21	27.	1.46	56.	.37	85.	.5
.20	30.39	.50	25.54	.20	16.57	.20	11.0	7.0	7.15	28.	1.41	57.	.35	86.	.4
.21	30.29	.51	25.45	.24	16.39	.24	10.52	.6	7.9	29.	1.37	58.	.34	87.	.3
.22	30.18	.52	25.36	.28	16.21	.28	10.44	.12	7.3	30.	1.33	59.	.33	88.	.2
.23	30.8	.53	25.27	.32	16.3	.32	10.36	.18	6.57	31.	1.29	60.	.31	89.	.1
.24	29.57	.54	25.18	.36	15.47	.36	10.28	.24	6.51	32.	1.26	61.	.30	90.	.0
.25	29.47	.55	25.10	.40	15.31	.40	10.20	.30	6.45	33.	1.23	62.	.29		
.26	29.37	.56	25.2	.44	15.25	.44	10.12	.36	6.39	34.	1.20	63.	.28		
.27	29.27	.57	24.54	.48	15.9	.48	10.4	.42	6.33	35.	1.17	64.	.27		
.28	29.17	.58	24.46	.52	14.53	.52	9.56	.48	6.27	36.	1.14	65.	.26		
.29	29.7	.59	24.39	.56	14.40	.56	9.48	.54	6.24						

Diffce. of Refraction for each Minute of Altitude 11″.

Diffce. of Refraction for each Minute of Altitude 9″.

Diffce. of Refracn. for 4′ Altitude 25″.

Diffce. of Refracn. for 4′ Altitude 18″.

Diffce. of Refracn. for 4′ Altitude 12″.

Diffce. of Refracn. for 4′ Altitude 16″.

For 6′ Alt. 14″.

For 6′ Alt. 8″.

For 6′ Alt. 8″.

Here the Differences of Refraction are for 60′ Altitude.

Here the Differences of Refraction are for 60′ Altitude.

Here the Differences of Refraction are for 60′ Altitude.

* Between No. 65 & 66 Fleet street.

Removed from Clements Inn and from Maiden Lane.

Published according to Act of Parliament July 14th. 1780. by S. Dunn No. 1. Boars-head Court Fleet street.

☽'s Altitude°	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	62′
	☽'s Parallax in Altitude.								
0	54′	55′	56′	57′	58′	59′	60′	61′	62′
1	4	5	6	7	8	9	0	1	2
2	4	5	6	7	8	9	0	1	2
3	4	5	6	7	8	9	0	1	2
4	4	5	6	7	8	9	0	1	2
5	4	5	6	7	8	9	0	1	2
6	4	5	6	7	8	9	0	1	2
7	4	5	6	7	8	9	0	1	2
8	3	4	5	6	7	8	59	0	1
9	3	4	5	6	7	8	9	0	1
10	3	4	5	6	7	8	9	0	1
11	3	4	5	6	7	8	9	0	1
12	3	4	5	6	7	8	9	0	1
13	3	4	5	6	6½	7	8	59	0
14	2	3	4	5	6	7	8	9	0
15	2	3	4	5	6	7	8	9	0
16	2	3	4	5	6	7	8	9	0
17	2	3	4	5	5	6	7	8	59
18	1	2	3	4	5	6	7	8	9
19	1	2	3	4	5	6	7	8	9
20	1	2	3	3½	4½	5	6	7	8
21	0	1	2	3	4	5	6	7	8
22	0	1	2	3	4	5	6	7	7
23	0	1	2	2	3	4	5	6	7
24	49	0	1	2	3	4	5	6	7
25	9	0	1	2	3	3	4	5	6
26	8½	49	0	1	2	3	4	5	6
27	8	9	0	1	2	3	3	4	5
28	8	9	49	0	1	2	3	4	5
29	7	48	8½	0	1	2	2	3	4

☽'s Altitude°	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	62′
	☽'s Parallax in Altitude.								
30	47′	48′	48½′	49′	50′	51′	52′	53′	54′
31	6	7	8	9	0	1	1	2	3
32	6	7	7	8	49	0	1	2	3
33	5	6	7	8	9	49	0	1	2
34	5	6	6	7	8	9	0	1	1
35	4	5	6	7	7½	8	49	0	1
36	4	4	5	6	7	7	9	49	0
37	3	4	5	5½	6	7	8	9	49
38	2	3	4	5	6	6	7	8	9
39	2	3	4	4	5	6	7	7	8
40	1	2	3	4	4	5	6	7	7
41	1	1½	2	3	4	5	5	6	7
42	0	1	2	2	3	4	5	5	6
43	39	0	1	2	2	3	4	5	5
44	9	0	0	1	2	2	3	4	5
45	8	39	0	0	1	2	2	3	4
46	7	8	39	0	0	1	2	2	3
47	7	7	8	39	0	0	1	2	2
48	6	7	7	8	39	39	0	1	1
49	5	6	7	7	8	9	39	0	1
50	5	5	6	7	7	8	9	39	0
51	4	5	5	6	6½	7	8	8	39
52	3	4	4	5	6	6	7	8	8
53	2	3	4	4	5	5½	6	7	7
54	2	2	3	3½	4	5	5	6	6
55	1	2	2	3	3	4	4	5	6
56	0	1	1	2	2	3	4	4	5
57	29	0	0½	1	2	2	3	3	4
58	9	29	0	0	1	1	2	2	3
59	8	8	29	29	0	0	1	1	2

☽'s Altitude°	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	62′
	☽'s Parallax in Altitude.								
60	27′	27½′	28′	28½′	29′	29½′	30′	30½′	31′
61	6	7	7	8	8	9	29	0	0
62	5	6	6	7	7	8	8	9	29
63	5	5	5	6	6	7	7	8	8
64	4	4	5	5	5	6	6	7	7
65	3	3	4	4	4½	5	5	6	6
66	2	2	3	3	4	4	4	5	5
67	1	1	2	2	3	3	3	4	4
68	0	1	1	1	2	2	2	3	3
69	19	0	0	0	1	1	1½	2	2
70	8	19	19	19	0	0	0½	1	1
71	8	8	8	9	19	19	0	0	0
72	7	7	7	8	8	8	19	19	19
73	6	6	6	7	7	7	8	8	8
74	5	5	5	6	6	6	7	7	7
75	4	4	4	5	5	5	6	6	6
76	3	3	4	4	4	4	4½	5	5
77	2	2	3	3	3	3	4	4	4
78	1	1	2	2	2	2	2	3	3
79	0	0	1	1	1	1	1	2	2
80	09	0	0	0	0	0	0	1	1
81	8	09	09	09	09	09	09	0	0
82	8	8	8	8	8	8	8	08	09
83	7	7	7	7	7	7	7	7	8
84	6	6	6	6	6	6	6	6	6
85	5	5	5	5	5	5	5	5	5
86	4	4	4	4	4	4	4	4	4
87	3	3	3	3	3	3	3	3	3
88	2	2	2	2	2	2	2	2	2
89	1	1	1	1	1	1	1	1′	1

Published according to Act of Parliament May 29. 1783 by S. Dunn, Fleetstreet London.

SECTION II.

A Table ſhewing the Increaſe of the Moon's Semidiameter, for her greateſt, mean and leaſt Diſtances from the Earth; and for every Five Degrees of Altitude.

Moon's Alt.	Moon's great. Diſt.	Moon's mean Diſt.	Moon's leaſt Diſt.
D.	"	"	"
0	0	0	0
5	1	1	2
10	2	3	3
15	3	4	5
20	5	3	6
25	6	7	8
30	7	8	9
35	8	9	11
40	9	10	12
45	10	11	13
50	11	12	14
55	11	13	15
60	12	14	16
65	13	14	17
70	13	15	18
75	13	15	18
80	14	16	18
85	14	16	19
90	14	16	19

EXAMPLE I.

Obſerved Alt.	10°.	15'.	0".
Hor. Semidiam.	0	14	44
Seconds for Alt.	0	0	3
true Semidiam.	0	14	47

EXAMPLE II.

Obſerved Alt.	40°.	0'.	0".
Hor. Semidiam.	0	16	8
Seconds for Alt.	0	0	10
true Semidiam.	0	16	18

EXAMPLE III.

Obſerved Alt.	80°.	0'.	0".
Hor. Semidiam.	0	16	42
Seconds for Alt.	0	0	18
true Semidiam.	80	17	0

SECTION III.

Of the Moon's Horizontal Parallax, and Parallax in Altitude.

The Moon's Horizontal Parallax, is the Angle made by two ſtraight lines, drawn from the Centre of the Moon, one to the Centre of the Earth, the other to its Surface. Thus the Horizontal Parallax is underſtood whether the Moon is in the Horizon or not; but, it will at all times be in the Horizon of ſome Place, of the Earth or Sea. Conſequently, the nearer the Moon is to the Earth, the greater is her Horizontal Parallax; and, there is the ſame Horizontal Parallax, whether the Moon is in the Horizon, the Zenith, or between the Horizon and Zenith, whilſt her Diſtance from the Earth is the ſame.

The Moon's Parallax in Altitude, is the Difference between the Altitude of the Moon as ſeen from the Surface of the Earth or Sea, and the Altitude which the Moon would have at the ſame time, if viewed from the Earth's Centre, and elevated above an Horizon a

Semidiameter of the Earth lower than that of its Surface. Consequently, the Moon's Parallax in Altitude is greatest near the Horizon; it decreaseth toward the Zenith, and in the Zenith it is nothing.

By the like Reasoning, the Moon's Semidiameter is least near the Horizon and greatest in the Zenith; at her greatest, mean and least Distances from the Earth.

At any given Altitude of the Moon, it is thus;
As the Radius or Sine of 90 Degrees,
Is to the Cosine of the Moon's Altitude observed;
So is the Horizontal Parallax, in Seconds of a Degree,
To the Parallax in Altitude, in Seconds of a Degree.

The Moon's Parallax in Altitude, added to the observed Altitude, clears the Altitude from Parallax in Altitude.

Annexed, is a Table shewing the Moon's Parallax in Altitude, for every Degree of Altitude, and every Minute of Horizontal Parallax, to the nearest Half Minute of Parallax in Altitude. In this Table, the Figure in Tens place upward, is supposed to be prefixed to each of the Figures under it.

In the Linear Tables, Article XIV, is a Table shewing the Parallax in Altitude for any Horizontal Parallax, and given Altitude, to the Exactness of a few Seconds, by Inspection. The use of this Table, is as follows.

Find the Moon's Altitude in the uppermost Line, and from it guide your eye slope-way from Right to Left downward, till you come to the Horizontal Parallax among the Horizontal Lines, and perpendicularly under this, is the Parallax in Altitude, in Minutes and Parts of a Minute, or in Seconds. Note, that the distance between one Perpendicular Line and another is 60″. By this Method, the Parallax in Altitude may be found, to less than 15″ instantly by Inspection; but, if greater Accuracy be required, with a pair of Compasses do thus,

From the Lowermost Line open the Compasses upward to the Horizontal Parallax, with which Extent remove to the slope of Altitude. Then, take the nearest Distance to the next Right-hand Perpendicular for additional Seconds, and measure them by the Scale at the left End. These added to the Seconds under the said Perpendicular, give the Parallax in Seconds, or in Minutes and Seconds.

This Method is not only expeditious but may be depended on to a few Seconds, and therefore may be of use in many Cases, where the greatest Accuracy is not wanted.

1st, By CALCULATION.

EXAMPLE I					EXAMPLE II.				
Moon's Alt.	34°	16′	0″	Log. 9.9172	Moon's Alt.	76°	48′	0″	Log. 9.3586
3560″ Hor. Par.	0	59	20	Log. 3.5514	3280″ Hor. Par.	0	54	40	Log. 3.5159
2942″ Par. Alt.	0	49	2	Log. 3.4686	749″ Par. Alt.	0	12	29	Log. 2.8745

In the two foregoing Examples, Radius is rejected in the Total of the Logarithms which are added together, to get the Logarithm of the Paralіax in Altitude.

2d, By CALCULATION and INSPECTION.

Examples.	Alt. of Moon.	Moon's Hor. Par.	Moon's Par. Alt.		Moon's Par. Alt.	Diff. by Inspection.
	° ′	′ ″	′ ″		″	″
1	55.56	60. 5	33.40	or	2020	3
2	18.56	55.30	52.30	or	3150	5
3	27. 2	59.58	53.26	or	3206	4
4	9.38	54.42	53.56	or	3236	5
5	49.57	57. 8	36.46	or	2206	4
6	47.42	57. 6	38.26	or	2306	1
7	30. 0	60. 0	51.58	or	3118	3
8	20. 9	57.24	53.54	or	3234	3
9	21.26	56.30	52.36	or	3156	5
10	15.21	60.25	58.16	or	3496	1
11	43.20	58.50	42.48	or	2568	3
12	20.34	56.24	52.48	or	3168	4
13	27.30	57. 3	50.36	or	3036	5
14	64.30	55.29	23.53	or	1433	0

By the above Examples, it appears that from this Table, the Parallax in Altitude may be taken without an Error of Six Seconds from the Truth; for the above Differences are all of one kind; and this may be of Use on many occasions when that Parallax is not wanted nearer the Truth, and even in many cases concerning the Longitude at Sea, as that Error alone would produce but an Error of Three Nautical Miles at the Equinoctial and Two coming into the British Channel.

Seeing that this Method of finding the Parallax in Altitude by Inspection is so accurate, it is applicable on several important occasions. In taking the Latitude by the Moon's observed Meridian Altitude, it clears that Altitude from Parallax in Altitude, to any desired Accuracy, with ease and certainty. The like for Altitudes of the Moon out the Meridian, in order to find the Latitude, Longitude, Azimuth and Time, from cotemporary Observations; for in either of these cases, the Refraction is subductive and the Parallax in Altitude additive, and from both of these the true Altitude is found. It is farther of great utility in finding the exact quantity of Refraction in Altitude near the Horizon in different Climates (a matter of the greatest consequeuce in taking the Longitude at Sea, as mentioned in my Treatise on that Subject) and farther, it is applicable with Facility, for finding the Deviation of the Spheroidal Horizon from that which would be formed on a Spherical Earth. Many other Uses of this Table might be mentioned.

D. M.	H.M. M.S.	D. M.	H.M. M.S.	D. M.	H.M. M.S.	D. M.	H.M. M.S.
0½	0. 2	15½	1. 2	30½	2. 2	45½	3. 2
1	0. 4	16	1. 4	31	2. 4	46	3. 4
1½	0. 6	16½	1. 6	31½	2. 6	46½	3. 6
2	0. 8	17	1. 8	32	2. 8	47	3. 8
2½	0.10	17½	1.10	32½	2.10	47½	3.10
3	0.12	18	1.12	33	2.12	48	3.12
3½	0.14	18½	1.14	33½	2.14	48½	3.14
4	0.16	19	1.16	34	2.16	49	3.16
4½	0.18	19½	1.18	34½	2.18	49½	3.18
5	0.20	20	1.20	35	2.20	50	3.20
5½	0.22	20½	1.22	35½	2.22	50½	3.22
6	0.24	21	1.24	36	2.24	51	3.24
6½	0.26	21½	1.26	36½	2.26	51½	3.26
7	0.28	22	1.28	37	2.28	52	3.28
7½	0.30	22½	1.30	37½	2.30	52½	3.30
8	0.32	23	1.32	38	2.32	53	3.32
8½	0.34	23½	1.34	38½	2.34	53½	3.34
9	0.36	24	1.36	39	2.36	54	3.36
9½	0.38	24½	1.38	39½	2.38	54½	3.38
10	0.40	25	1.40	40	2.40	55	3.40
10½	0.42	25½	1.42	40½	2.42	55½	3.42
11	0.44	26	1.44	41	2.44	56	3.44
11½	0.46	26½	1.46	41½	2.46	56½	3.46
12	0.48	27	1.48	42	2.48	57	3.48
12½	0.50	27½	1.50	42½	2.50	57½	3.50
13	0.52	28	1.52	43	2.52	58	3.52
13½	0.54	28½	1.54	43½	2.54	58½	3.54
14	0.56	29	1.56	44	2.56	59	3.56
14½	0.58	29½	1.58	44½	2.58	59½	3.58
15	1. 0	30	2. 0	45	3. 0	60	4. 0

SECTION IV.

In this Table, each Degree is four Minutes of Time, and each Minute of a Degree is four Seconds of Time. An Hour of Time is fifteen Degrees, and a Minute of Time is fifteen Minutes of a Degree.

When either the Degrees or the Minutes of a Degree do not exceed Sixty, the Time is opposite to them in the First part of the Table. Consequently, when the Time doth not exceed four Hours, the Degrees are opposite thereto; and when the Time doth not exceed four Minutes, the Minutes are opposite thereto, to the nearest half Minute, in the same part of the Table.

When the Degrees are between Sixty and One Hundred and Eighty, the Hours and Minutes are opposite to them in the Second part of the Table. When the Degrees exceed One Hundred and Eighty, the Excess must be found by Subtraction and against the Remainder

D.	H. M.	D.	H. M.	D.	H. M.	D.	H. M.
61	4. 4	91	6. 4	121	8. 4	151	10. 4
62	4. 8	92	6. 8	122	8. 8	152	10. 8
63	4.12	93	6.12	123	8.12	153	10.12
64	4.16	94	6.16	124	8.16	154	10.16
65	4.20	95	6.20	125	8.20	155	10.20
66	4.24	96	6.24	126	8.24	156	10.24
67	4.28	97	6.28	127	8.28	157	10.28
68	4.32	98	6.32	128	8.32	158	10.32
69	4.36	99	6.36	129	8.36	159	10.36
70	4.40	100	6.40	130	8.40	160	10.40
71	4.44	101	6.44	131	8.44	161	10.44
72	4.48	102	6.48	132	8.48	162	10.48
73	4.52	103	6.52	133	8.52	163	10.52
74	4.56	104	6.56	134	8.56	164	10.56
75	5. 0	105	7. 0	135	9. 0	165	11. 0
76	5. 4	106	7. 4	136	9. 4	166	11. 4
77	5. 8	107	7. 8	137	9. 8	167	11. 8
78	5.12	108	7.12	138	9.12	168	11.12
79	5.16	109	7.16	139	9.16	169	11.16
80	5.20	110	7.20	140	9.20	170	11.20
81	5.24	111	7.24	141	9.24	171	11.24
82	5.28	112	7.28	142	9.28	172	11.28
83	5.32	113	7.32	143	9.32	173	11.32
84	5.36	114	7.36	144	9.36	174	11.36
85	5.40	115	7.40	145	9.40	175	11.40
86	5.44	116	7.44	146	9.44	176	11.44
87	5.48	117	7.48	147	9.48	177	11.48
88	5.52	118	7.52	148	9.52	178	11.52
89	5.56	119	7.56	149	9.56	179	11.56
90	6. 0	120	8. 0	150	10.0	180	12. 0

Remainder are the Hours and Minutes in one of the parts of the Table, which being added to Twelve Hours gives the Time required.

The Reverſe, gives the Degrees and Minutes, to the neareſt Half Minute of a Degree.

EXAMPLE I.

	°	′		H	′	″
	67	$24\frac{1}{2}$	is	4	29	38
for	67	0	=	4	28	0
		$24\frac{1}{2}$	=		1	38

EXAMPLE II.

	°	′		H	′	″
	163	$40\frac{1}{2}$	is	10	54	42
for	163	0	=	10	52	0
		40	=		2	42

EXAMPLE III.

	°	′		H	′	″
	236	$18\frac{1}{2}$	is	15	45	14
for	180	0	=	12	0	0
	56	0	=	3	44	0
		$18\frac{1}{2}$	=		1	14

EXAMPLE IV.

	H	′	″		°	′
	19	47	26	is	296	$51\frac{1}{2}$
for	12	0	0	=	180	0
	7	44	0	=	116	0
		3	26	=		$51\frac{1}{2}$

A New

A New Table shewing the Dip of Horizon to 600 Feet above the Surface of the Sea; with its Use in determining the Horizontal Distances of Objects.

Feet.	Dip.	Feet.	Dip.	Feet.	Dip.	Feet.	Dip.	Feet.	Dip
	′ ″		′ ″		′ ″		′ ″		′ ″
0	0. 0	25	5.18	55	7.53	180	14.15	310	18.41
1	1. 4	26	5.25	60	8.14	185	14.26	320	18.59
2	1.30	27	5.31	65	8.34	190	14.38	330	19.17
3	1.50	28	5.37	70	8.53	195	14.50	340	19.54
4	2. 7	29	5.43	75	9.12	200	15. 1	350	19.52
5	2.23	30	5.49	80	9.30	205	15.12	360	20. 8
6	2.36	31	5.55	85	9.47	210	15.23	370	20.25
7	2.49	32	6. 1	90	10. 4	215	15.34	380	20.41
8	3. 0	33	6. 6	95	10.21	220	15.44	390	20.58
9	3.11	34	6.11	100	10.37	225	15.55	400	21.14
10	3.22	35	6.17	105	10.53	230	16. 6	410	21.30
11	3.31	36	6.22	110	11. 8	235	16.17	420	21.45
12	3.41	37	6.27	115	11.23	240	16.27	430	22. 1
13	3.50	38	6.32	120	11.38	245	16.37	440	22.16
14	3.58	39	6.37	125	11.52	250	16.47	450	23. 1
15	4. 7	40	6.43	130	12. 6	255	16.57	500	23.45
16	4.14	41	6.48	135	12.20	260	17. 7	510	23.59
17	4.23	42	6.53	140	12.34	265	17.17	520	24.13
18	4.30	43	6.58	145	12.47	270	17.27	530	24.26
19	4.38	44	7. 3	150	13. 0	275	17.37	540	24.40
20	4.45	45	7. 8	155	13.13	280	17.46	550	24.54
21	4.52	46	7.12	160	13.26	285	17.55	560	25. 7
22	4.58	47	7.17	165	13.38	290	18. 5	570	25.21
23	5. 5	48	7.21	170	13.50	295	18.14	580	25.34
24	5.12	49	7.26	175	14. 3	300	18.23	590	25.47
25	5.18	50	7.30	180	14.15	305	18.32	600	26. 0

The Height to which this Table is carried above the Surface of the Sea, is sufficient for all cases wherein the Dip is wanted to be known in order to clear the observed Altitude of either Sun, Moon or Star. It is calculated anew from proper Data. At the Height of a Ship's Deck, it gives the Dip Half a Minute of a Degree more than some, and less than others, who have been esteemed our best Writers on this Subject. Whilst such Uncertainties have been concerning the Quantity of Dip, Corrections of the observed Altitudes to Seconds of a Degree, must have been needless.

SECTION

SECTION V.

Of the Dip or Depression of the Apparent Horizon, below the Horizon of the Sea.

When the Eye of an Observer is either in or supposed to be in the Surface of the Sea; the Celestial Bodies appearing to coincide with the Surface of the Sea, are said to be in the true Horizon of the Sea at that Place; but if the Eye be above the Surface of the Sea, the same Bodies at the same time appear Elevated a certain number of Seconds, or Minutes and Seconds of a Degree. This Elevation is called the Dip of Horizon, and is to be subtracted from the observed Altitude, to clear it therefrom.

A Table shewing the Dip of Horizon having the Height of the Eye above the Surface of the Sea, is made, by having the Diameter of the Earth in Feet, and the Height of the Eye in Feet. If the former of these is not near the Truth, the Table will not be quite correct. I have computed the annexed Table, from the latest Discoveries concerning the Dimensions of the Ear.h's Diameter.

The first part of this Table, will answer for all the usual cases, when Altitudes have been taken in any part of a Ship at Sea; the second part will be of use for ascertaining Distances of places from the Ship.

In this Table, fixty second make a Minute or Nautical Mile, and the Nautical Mile is to the English Mile, as 60 to 70 nearly; therefore, when the Nautical Miles are found, take its Sixth part and add it to them, this gives the English Miles nearly.

The Alteration of the Position of the Horizon of a Place, is a Minute of a Degree in each Nautical Mile; therefore, the Dip of Horizon being accurately known, the Distance is also known as in the following Examples.

EXAMPLE I.

Height 24 Feet			
Altitude observed	32°.	30′	0″.
Dip of Hor.zon	0.	6	3.
Altitude cleared	32	23	57.

EXAMPLE II.

Height 120 Feet.			
Altitude observed	25°.	15′.	0″.
Dip of Horizon	0.	5.	20.
Altitude cleared	25.	9.	40.

EXAMPLE III.

Height 150 Feet.			
Farthest Surface at Sea	0°.	13′.	0″.
Nautical Miles		13 miles.	
English Miles		15⅙ miles.	

EXAMPLE IV.

Height of a Ship's Deck	60 Feet.	
Height of another's Deck	50 Feet.	
Dip for first Ship	8′.	14″.
Dip for second Ship	7.	30
Ships Distance apart	15.	44
Nautical Miles	15¾ miles.	
English Miles	18⅜ miles.	

EXAMPLE V.

Height of a Light House	600 Feet.
Its Light ho.izontal at Sea.	
Distance in N. Miles	26 Miles.
E. Miles	30⅓ Miles.

EXAMPLE VI.

Height of a Hill	500 Feet.	
Height of a Mast	100 Feet.	
Dip for the Hill	23′.	45″.
Dip for the Mast	10′.	37″.
Dip for both	34′.	22″.
Make Nautical Miles	34⅓ miles.	
And English Miles	40 miles.	
Distance when their Tops in the Horizon.		

EXAMPLE VII.

¾ Height of one Hill	500	Feet.
¾ Height of another Hill	450	Feet.
Dip for both Heights	46′.	46″.
Distancein N. Miles	46¾	Miles.
Distance in E. Miles	54½	Miles.
When ¾ Heights appear in the Horizon.		

SECTION VI.

Of LARGE TABLE I. in the Linear Table.

This Table has three Lines; 1st. Lines drawn from the Left hand toward the Right, beginning at 4° and ending at 50°. In some part or other of these, the Lesser Altitude of Sun, Moon or Star, is found in computing the Longitude. 2d. Lines drawn perpendicular to and crossing the former, beginning at 8°, and ending at 90°. In some part or other of these, the Greater Altitude is found. 3d. Lines crossing the two former, and numbered with Index 2. and three Figures following it.

When a Number is to be found by this Table, the lesser and greater Altitudes are to be found as before directed, and in the Angle of meeting is the Number sought, amongst the third sort of Lines beforementioned.

The best Observations that has been made in different Climates, prove that at the Altitude of a few Degrees, the Refraction may be too imperfectly known, for a desired Determination of the Longitude by the Lunar Method. There are proofs of such uncertainty, as high as eight or ten Degrees of Altitude; this renders lesser Altitudes of less consequence, and shews that the success is chiefly to be expected from greater Altitudes.

When the Point is found where the Lines of lesser and greater Altitude meet in this Table, it is to be observed that, near that Point, the Distance between two Lines of the third sort contains ten Units, and as many of these as that Point is past the foregoing Line, being added to its Number, gives the Number required.

In taking out the Number from this Table, there is no particular Nicety required, but what the Eye can immediately discern and the Judgment determine, except when one of the Altitudes is very near the Horizon; and then, the Error may be greater through the uncertainty concerning Refraction, than that of applying this Table.

When the Number is thus found, it is to be worked as the Formula directs, until Number A is found.

When the two Lines of Direction from the Lesser and greater Altitude, do not fall within this Table but without it, neither this Table, nor Table II. following it are to be applied, but Table III. as is directed in the Use of that Table farther on.

In using this Table I. the Number may be taken out in usual cases, to the nearest Quarter of a Degree for both the lesser and greater Altitude, and in some cases to twice that number of times if not more, without ever needing Proportional Parts for any place in the Table; which is a great Advantage over the Numerical Method of Expression.

This Table is illustrated, in finding the Correction for Refraction, in the Examples farther on.

LONGITUDE Instructions; By S. Dunn.

1. Get the Altitude of the Sun's Centre cleared from Dip & Semidiameter, the Altitude of the Moon's Centre cleared from Dip & Semidiameter, & the Sun & Moon's nearest Limbs. ..... Add 32′ to the observed Distance of Limbs to get the Rough Central Distance. with this from Ephemeris page 8, 9, 10 or 11 for the Month, where the Day of the Month & Sun are together take out the nearest Hour; this is the rough Hour for Greenwich.

2. The Ephemeris has the

Sun's true Semidiameter .... page ... 3.
Moon's true Semidiameter .... 7.
Moon's Horizontal Parallax .... 7.
Three hourly Distances ..... 8, 9. 10. 11.
Sun's true Declination .... 2.

The Requisite Tables have the

Seconds for Moon's Altitude .. page - 153.
Refraction in Altitude .... 2.
Moon's Parallax in Altitude ... 3, 4, 5.
Time & Degrees .... 6.

3. Begin the Formula with the Rough Central Distance & Rough Hour for Greenwich, & go on as it directs until you come to the Number E in it. Then, in usual Cases, the nearer the Rough Central Distance in Degrees, comes to 120°, the greater it is; & the nearer it comes to 20°, the less it is. A great Altitude of the Moon may be that above 20°. When the Rough Central Distance in Degrees is great, & especially, when the Moon's Altitude is also great; then Number E may be written for the true Distance of Centres.

4. For small Distances, or small Moon's Altitude, Take the Moon's Parallax in Altitude from Requisite Tables page 3, 4, 5; with this & the Distance take the Seconds from large Table IV. Also with Number C & the Distance, take the Seconds from the same Table IV; & the Difference of these Seconds is F.

5. From amongst the three hourly Distances in Ephemeris page 8, 9, 10 or 11, take two such Distances following each other, so that the true Distance of the Centres falls between them; then go on by the Formula till you have the Time at Greenwich; this is past noon for Greenwich.

6. From Ephemeris page 2. take the Sun's true Declination for the Hour at Greenwich; & when the Declination & Latitude are both North or both South, subtract the Declination from 90°; but in other Cases, add the Declination to 90°, to get the Polar distance. And subtract the Sun's Coaltitude from the Half sum to get a Remainder. Then go on by the Formula, till you have the Time at the Ship; this will be past Noon at the Ship in an Afternoon Observation, & short of noon in a Fornoon Observation.

7. In an Afternoon Observation, subtract one Time from the other, the Remainder is the Longitude; & it is West Longitude when the Time at Greenwich is greatest, but otherwise East Longitude. In a Fornoon Observation, add the two Times together, the Sum is the Longitude West, & it's Remainder to either 24 Hours or 360°, is East Longitude.

NB. These general Precepts, in several Parts of the Operation, may be shortened, by attending to the following Directions concerning each in particular.

Published according to Act of Parliament May 29th 1782 by Samuel Dunn, Fleetstreet London.

S. Dunn inv.t & delin.t

Supplementary LONGITUDE Instructions; By S. Dunn.

Of Preparations.

1. When the Sun & Moon's nearest Limbs have been observed; add 32′ to get the Rough Central Distance. Also, add the Sun & Moon's true Semidiameters, & Seconds for Moon's Altitude; to get L.

2. When the Star & Moon's nearest Limb have been observed; add 16′ to get the Rough Central Distance. Also add the Moon's true Semidiameter, & Seconds for Moon's Altitude, to get L.

3. When the Star & Moon's farthest Limb have been observed; subtract 16′ to get the Rough Central Distance. Also, subtract the Moon's true Semidiameter, & Seconds for Moon's Altitude, to get L.

Of Contractions.

1. In taking out the Number from large Table I, the nearest whole Degrees may be used in the most usual Cases.

2. When the Number falls above or near the Crooked Line in large Table I, you need not find the Numbers A, B; but take from large Table III, the Seconds that are to be added to Number L, to give Number D.

3. When the Sun or Moon's Altitude is very small, the Refraction should be taken from the Altitude, before it is written in the Formula, next after the Horizontal Parallax.

4. In computing the Time at the Ship; the third Number or Sun's Co-altitude, is that of the Altitude lessened both by Dip & Refraction.

Of Operations.

1. The Observations should not be made when the Sun or Moon are very near the Horizon. If the Moon is very near the Horizon, Proportional Parts should be used in large Table I.

2. Four Places of Logarithms with Index, are used, till the last Cosine; then the fifth Figure is 5 when 1 remains, & 0 when 0 remains.

3. C must not be added to D, unless the 1st Arc is least of the two Arcs, & at the same time D is less than 90°. In other Cases, subtract C from D.

Of Observations.

1. In observing for Longitude only, without use of a Watch, the Sun should not be very near the Meridian; then Observations will determine Latitude. Also, when the Moon is near the Meridian, Observations will determine Latitude.

2. When the Sun is far à Meridian & not near the Horizon, Observations are best for the Time & setting a Watch.

3. In the Night, the Watch shews Time at the Ship. When no Watch is used in the Night, the Right Ascension of Sun & Star, compared with the Star's distance from the Meridian, either past or short of it, gives Time at the Ship. In this, the Chart of Zodiacal Stars is useful.

4. The Stars of first Magnitude out of the Zodiac, are useful for Time at the Ship; such as Capella, the principal in Orion, Canopus, Sirius, Procyon, Lyra. And so may Venus, Mars, Jupiter & Saturn.

5. The same Stars & Planets may be used for Latitude by Meridian Altitudes, Elapsed Time, & otherwise.

6. The principal Stars used in the Lunar Method are, Aldebaran, Pollux, Regulus, Spica, Antares, Aquila, Fomalhaut. The others are, Capella, Orion's Sirius, Procyon, Canopus, Arcturus, Lyra; the Bears, Ship & Cross.

Published according to Act of Parliament May 29th. 1782 by Samuel Dunn, Fleetstreet London.

S. Dunn inv. & delin.

SECTION VII.

Of LARGE TABLE II. in the Linear Tables.

In this Table, L is the obſerved Diſtance of Centres, and B the Number of Seconds to be taken out, and added to or ſubtracted from A. In doing this, if L be near 90 Degrees, it is to be found to the neareſt Half Degree; but if it be near the Middle of the Quadrant, it ſhould be taken to the neareſt Quarter of a Degree; and if it be toward the Beginning of the Quadrant, as from 20 to 15 and 10 Degree, it ſhould be taken to the neareſt Half-quarter of a Degree; and oppoſite thereto is the Number B in Seconds, which are to be added to, or ſubtracted from A, as denoted at the Top of the Table, to give the Correction additive to L to give D.

This Table is illuſtrated, in finding the Correction for Refraction, in the Examples farther on.

SECTION VIII.

Of LARGE TABLE III. in the Linear Tables.

This Table is to be uſed when Large Table I. will anſwer to no Number by the Interſection of Lines within it. As in large Table II. ſo here, L is to be taken to either Half or Quarter or Half a Quarter of a Degree; and againſt it is the Number of Seconds and part of a Second (which are here called B) and are to be added to L to give D.

This Table is illuſtrated, in finding the Correction for Refraction in the Examples farther on.

SECTION IX.

Of LARGE TABLE IV. in the Linear Tables.

When the Obſerved Diſtance of Centres hath been cleared from Refraction and Parallax, by either of the Methods treated of in the *Theory and Practice of Longitude at Sea*, or that by either of the two Formulas in this Treatiſe; there is a ſmall Correction to be farther made, for ſmall Diſtances and ſmall Altitudes of the Moon, which is moſt eaſily done by this Table.

This Table hath three different Sorts of Lines; 1ſt. Perpendicular lines leading from the Numbers 10°. 20°. &c. to 90° and returning again to 120° in ſome Part of theſe, the Diſtance L or rather E is found. 2d. Parallel Lines drawn from left to right, from the Numbers 10′. 22′. &c. to 62′. in ſome Part of theſe, the Moon's Parallax in Altitude is found. 3d. Lines which are partly curved, drawn acroſs the Table; amongſt theſe latter (as in large Table 1.) is the laſt Correction F expreſſed in Seconds at the End of the

 Lines,

Lines, when the Correction C is found as a Parallax in Altitude, and E as a Distance, and the Angle of their Meeting falls without the Table; but when these meet within the Table, the Number found by the Curve lines must be taken from that Correction and the Remainder is F.

As Table I. is expressive of Answers to any Part of a Degree for both Altitudes, so is this Table IV. to any Part of a Minute of Parallax in Altitude, and any Part of a Degree of Distance; and therefore, both of these Tables are contained in a much less Compass than this could be expressed Numerically in any manner whatever. At the same time, no proportional Parts ever come in question.

This Table is illustrated, in finding the last Correction for Refraction and Parallax, in the Examples farther on.

SECTION X.

Of TABLE V. in the Linear Tables.

In this Table, the Lines 1, 1; 2, 2; 3, 3; &c. do each of them contain 10 equal Parts. Therefore, if the Distance of any two Lines of the third Sort in Large Table I. be found among these Lines; any intermediate Distance between the Lines, is hereby easily found to a tenth Part of the whole.

This Method may be applied by help of a pair of compasses, to come to the greatest Accuracy by Table I. but it is not necessary in usual Practice. The Correction depending on Large Table I. is generally but small, except when one of the Altitudes is very small, and then (as hath been before noted, its Refraction cannot be depended on and a greater Error may arise therefrom. The peculiar Property of this Table, is that of giving Ansswer to a Multitude of Questions, instantly without proportional Parts, and all sufficiently exact for Use, although the Table is comprised in so small a Compass.

SECTION XI.

Of TABLE VI. in the Linear Tables.

This Table is a Supplement to Table II. and applied only when the lesser Altitude is from Eight to Four Degrees. In such Cases, the Distance of Centres is to be found in the Side of the Table to the nearest Ten Degrees, and against it is a Number of Seconds, which being subtracted from B, as it is taken from Table II. gives the Correct B, which is to be applied as directed in the Use of that Table.

SECTION

SECTION XII.

Of the PROPER LOGARITHMS, in the Linear Tables.

The Logarithms which are of most general Use are, first the Logarithms of Numbers, these are commonly called Common Logarithms; secondly, Log-sines, Log tangents and Log-secants.

When of four Terms in Direct Proportionality, three are given to find the fourth, and the first and third Terms do each consist of Minutes and Seconds, but the second Term is Unity; in order to take off the trouble of reducing the first and third Terms to Seconds, and other tedious Multiplication and Division, Proper Logarithms are applied which bring out the Answer by a single Subtraction.

Although these Proper Logarithms are commonly carried to but four Places of Figures beside the Index, yet when Unity is the Middle Term, they are sufficient for this Purpose, because Unity is their Difference throughout almost all the last Quarter of the Table. In almost all the third Quarter the Difference is Two; throughout the second Quarter it is from Three to Five; and near the Middle of the first Quarter it is nine.

The same Logarithms may be made applicable, if Two, Three or Four, be the Middle Term, with this Alteration. If Two be the Middle Term, the Degrees Minutes and Seconds belonging to the respective Logarithms must be doubled; if Three be the Middle Term, the Logarithms must be trebled; if Four, they must be quadrupled, &c.

If they are trebled whilst the Logarithms remain the same, there will be either Uncertainty or Error of two Seconds of a Degree, in the last Quarter of the Table; and a Second of a Degree in a great Part of the third Quarter; and as often as these Errors are repeated in a Computation, so much greater is the Error thereby upon the whole.

The only apparent Remedy to these Defects, without working Proportional Parts, is the Bisection of the trebled Minutes and Seconds; for by this Method, in these uncertain Parts of the Table, whatever the Logarithm happens to be, its correspondent Number is taken out to the nearest Half Second by Inspection.

SECTION XIII.

A Description of the TABLE of PROPER LOGARITHMS.

At the Top of the Table are the Degrees and Minutes, marked in a successive Order to each Minute, and in the Side are the Seconds in

in two Columns, to every Three Seconds, the innermost Column of Seconds belonging to the Logarithms, and the outermost belonging to the Medium of the two Logarithms one above and the other below the Line in which they stand. The left hand leading Figure or Figures of the Logarithms, repeat or are supposedly prefixed to those right hand Figures which are under them.

At the Bottom of the Table is a Row of Figures, shewing the mean Difference of the Logarithms in the Columns over which they stand; and underneath that is a Row of Degrees and Minutes, beginning with O, and increasing by 15 Minutes of a Degree, to the End of the Table. At the outermost Column of Seconds, are small Marks a little above and below the Lines on which the Figures stand.

SECTION XIV.

How to take out the PROPER LOGARITHMS; and their Degrees, Minutes and Seconds.

1st. When the Degrees and Minutes are found at the Top of the Table, and the Seconds can be exactly had in the innermost Column at the Side, the Logarithm is at the Angle of Meeting in the Table.

2d. When the Seconds are found in the outside Column of the Table, the Medium of the right hand Figures of the Logarithm, with its prefixed left hand Figures, is the Logarithm required. In this Case, it appears by Inspection, that throughout almost all the latter half of the Table, the Differences of the Logarithms will not trisect; and that therefore they are not continued to Places enough for shewing the Logarithm to the nearest Second by such a Trisection.

3d. Since the inner and outer Columns of Seconds, do exhaust all Numbers in a successive order to the nearest Half Second, no Error whatever can happen by the above Method of using the second Half Part, nor an Error greater than Half a Second, by using the first Half Part of the Table. But, if greater Accuracy be wanted in the first Half of the Table, the Medium of the Logarithms compared with a given Logarithm, will shew whether the half Second is to be added to or subtracted from that in the outermost Column, to give the Truth required.

SECTION XV.

Of TABLE XII. in the Linear Tables.

This Table begins at O, and goes on to either Three Hours or Three Degrees and shewing by Inspection both the Seconds of Time and

and the Seconds of a Degree; to either of which, add any given Number of Seconds, and the Total ſhews the Seconds in a given Number of either Hours, Minutes and Seconds, or of Degrees, Minutes and Seconds.

The Reverſe of this turns Seconds into Time, or Degrees.

EXAMPLE I.					EXAMPLE II.				
H	′	″		″	″		H	′	″
2	27	53	=	8873.	5679	=	1	34	39.
for 2	27	0	=	8820.	for 5640	=	1	34	0.
				53.	39	=			39.

SECTION XVI.

Of TABLE XIII. in the Linear Tables.

This Table is of the ſame kind as that deſcribed in Section IV. as far as Sixty Minutes, which may likewiſe expreſs Sixty Degrees. For Degrees above Sixty, this Table goes on by Tens to 360 Degrees or 24 Hours of Time.

SECTION XVII.

Of finding the True Diſtance of Centres of either Sun and Moon or Moon and Sun; having the Obſerved Diſtance of their Limbs.

In this work are two Formulas for computing not only the true Diſtance of Centres, but the whole Calculation for Longitude from Greenwich.

The firſt of theſe Formulas, finds the Effect of Refraction, which (in almoſt all practical Caſes) is ſmall, although the caſes are numerous; and then the Effect of Parallax.

The ſecond Formula works the joint Effect of Refraction and Parallax together.

The Longitude Inſtructions, ſhew the Order of theſe Operations, until Number E is found, in both Methods; then F is found, by the Directions in the Deſcription and Uſe of Table IV.

When a Table conſiſting wholly of Numbers, increaſeth deſcending perpendicularly but decreaſeth horizontally, from one Degree to another, and Proportional Parts are to be worked for intermediate Minutes, this becomes a troubleſome taſk to good Computors, and to indifferent ones it is ſometimes inſuperable. This was the caſe in Lyons's large Table I. and what put me under the neceſſity of ſubſtituting ſome eaſy Expedient affected with but ſmall Error, which was that of the neareſt whole Degree to thoſe of the Obſervation.

By this Method the Difficulty was overcome, and the Error in uſual

usual Cases, seldom exceeded a few Seconds of a Degree; but this is wholly removed by the Construction and Use of the Linear Table I.

In the Use of this Table it is not necessary that the Computor should take out the third Figure in Thousandths Place to an Unit. Amongst the twenty two Examples following (which are almost all formed by such Data as would shew a Defect in this Table I. if there were any Defect in it) there is not one, but in it any Computor (however slow of apprehension) can take out the Number instantly without erring Five, and it might be said without erring Two in the greatest part of them. If that Error amounted to Ten (which can never happen under the least Judgment and Attention) the Errors thereby would be no more in Longitude at the Equinoctial, than the following; in the Channel the Miles would be but two thirds of those at the Equinoctial.

A View of the Errors at the Equinoctial, that would arise by increasing or diminishing the N° taken out of Linear Table I. by an Error of Ten Units.

		Error	Miles			Error	Miles
Example	I.	— 4″	= 2	Example	XII.	— 6″	= 3
	II.	— 9	= 4½		XIII.	— 5	= 2½
	III.	— Absurdity.			XIV.	— 3	= 1½
	IV.	— Absurdity.			XV.	— 6	= 3
	V.	— 2	= 1		XVI.	— 3	= 1½
	VI.	— 2	= 1		XVII.	— not used.	
	VII.	— not used.			XVIII.	— 3	= 1½
	VIII.	— 3	= 1½		XIX.	— not used.	
	IX.	— 3	= 1½		XX.	— not used.	
	X.	— not used.			XXI.	— 7	= 3½
	XI.	— 4	= 2		XXII.	— 4	= 2

The greatest Error that an indifferent Computor may happen to make in applying this Table, is when one Altitude is very small and the other very great; in such a Case, it appears from the Construction, that there cannot be an Error of Five in the third right hand Place, and this at the Equinoctial would produce an Error not exceeding Two Miles; in all other Cases the Error hereby would be less, and frequently vanish. But even in this particular Case, the Error through unknown Refraction near the Horizon, and an incorrect observed Distance of the Limbs, will be many times greater, and thereby render such as this of a very trifling Effect.

From such considerations as these, it will be easy to assign the Limits for greater and lesser Altitude, within which the Uncertainty of Refraction may not render the Longitude but little more affected with Error than what arises from the Imperfections of the Observations and Predictions in the Tables.

EXAMPLE

EXAMPLE I.

	°	′	″
" Distance observed	51	28	35"
Star's Altitude	24	48	5
Moon's Altitude	12	30	5
Moon's Hor. Par.	0	56	15

Required the true Dist. of Centers?

1st. By Linear Tables.

N° in Table I. -			2.136
Co. ar. of Distance			0.107
175″ Com. Log. Sum			2.243
87 in Table II.	°	′	″
88 Correction	0	1	28
Dist. observed	51	28	35
D =	51	30	9
1st Arc =	0	30	7
2d Arc =	0	9	38
C =	0	20	29
D =	51	30	3
E =	51	9	34
F =	0	0	20
P =	51	9	54

2d. By Sun & Moon's Angles.

	°	′	″
M =	68	8	
S =	93	38	
A =			1133″
B =			10
C =	0	19	3
D =	51	28	35
E =	51	9	32
F =	0	0	20
P =	51	9	52

3d. By different Methods.

	°	′	″
1. By the Linear Tables	51	9	54
2. By Sun and Moon's Angles	51	9	52
3. By Lyons's whole Degrees	51	9	51
4. By Mr. Lyons himself	51	9	52
5. By Ditto altered -	51	9	51
6. By Mr. Dunthorne himself	51	9	54
7. By Ditto altered -	51	9	51

EXAMPLE II.

	°	′	″
" Distance observed	90	21	13".
Star's Altitude	84	7	6
Moon's Altitude	5	17	8
Moon's Hor. Par.	1	1	48

Required the true Dist. of Centres?

1st. By Linear Tables.

N° in Table I. -			2.758
Co. ar. of Distance			0.000
573″ Com. Log. Sum			2.758
0 in Table II;	°	′	″
573 Correction	0	9	33
Dist. observed	90	21	13
D =	90	30	46
1st Arc =	1	1	29
2d Arc =	0	0	3
C =	1	1	32
D =	90	30	46
E =	89	29	14
F =	0	0	1
P =	89	29	13

2d. By Sun & Moon's Angles.

	°	′	″
M =	3	0	
S =	17	20	
A =			3119″
B =			5
C =	0	51	54
D =	90	21	13
E =	89	29	19
F =	0	0	1
P =	89	29	20

3d. By different Methods.

	°	′	″
1. By the Linear Tables	89	29	13
2. By Sun and Moon's Angles	89	29	20
3. By Lyons's whole Degrees	89	29	17
4. By Lyons altered -	89	29	10
5. By Dunthorne altered	89	29	20
6. By Ditto again altered	89	29	15

EXAMPLE III.

	°	′	″
" Diſtance obſerved	89	58	6"
Star's Altitude	5	6	5
Moon's Altitude	88	46	5
Moon's Hor. Par.	1	1	18

Required the true Diſt. of Centres?

1ſt. By Linear Tables.

Nº in Table I.			2.773
Co. ar. of Diſt. obſerved			0.000
593″ Com. Log. Sum			2.773
0 in Table II.	°	′	″
593 Correction	0	9	53
Diſt. obſerved	89	58	6
D =	90	7	59
1ſt Arc =	0	5	16
2d Arc =	0	0	8
C =	0	5	8
D =	90	7	59
E =	90	2	51
F =	0	0	0
P =	90	2	51

2d. By different Methods.

	°	′	″
1. By the Linear Tables	90	2	51
2. By Sun & Moon's Angles, an Abſurdity.			
3. By Lyons's whole Degrees	90	2	43
4. By Lyons altered	90	2	36
5. By Dunthorne altered	90	2	26
6. By Ditto again altered	90	2	32

EXAMPLE IV.

	°	′	″
" Diſtance obſerved	103	29	27"
Sun's Altitude	19	3	35
Moon's Altitude	71	6	0
Moon's Hor. Par.	0	58	34

Required the true Diſt. of Centres?

1ſt. By Linear Tables.

Nº in Table I.			2.265
Co. ar. of Diſt. obſerved			0.012
189″ Com. Log. Sum			2.277
26 in Table II.	°	′	″
215 Correction	0	3	35
Diſt. obſerved	103	29	27
D =	103	29	27
1ſt Arc =	0	19	38
2d Arc =	0	13	21
C =	0	32	59
D =	103	33	2
E =	103	0	3
F =	0	0	0
P =	103	0	3

2d. By different Methods.

	°	′	″
1. By the Linear Tables	103	0	3
2. By Sun & Moon's Angles, an Abſurdity.			
3. By Lyons's whole Degrees	103	0	4
4. By Lyons altered	102	59	54½
5. By Dunthorne altered	102	59	55
6. By Ditto again altered	102	59	56

The two foregoing Examples have nearly the ſame Data, as two of four publiſhed and ſolved in a certain Book of Tables; and theſe are here introduced, only to ſhew the Abſurdity of ſuch Queſtions.

When the Cotemporary Obſervations are made, the Obſerved Co-altitude of Sun or Star, the Obſerved Co-altitude of the Moon, and the Obſerved Diſtance of the Limbs, do always form a Spherical Triangle, in which any two of its Sides, are together greater than the third Side. But in both of theſe Queſtions, the two Co-altitudes together make leſs than the Diſtance; conſequently, they are both of them abſurd and unanſwerable, and the Corrections for their Refraction and Parallax, belong to other Data.

EXAMPLE

A New and Easy FORMULA for the LONGITUDE by SUN and MOON. By S. Dunn

Central Dist. — Hours at Greenw. ° ′ ″

☉ & ☽'s Limbs observed
☉'s true Semidiameter
☽'s true Semidiameter
Parts for ☽'s Altitude

Observed dist. of Centres =L

Least Alt. Centre clear
Greater Alt. Centre clear
Parts by Top & Side Tab. 1 2.
Dist. Centres Co. ar.

A = ″ Common Logar.^{m}
B = Parts in Tab. II. add if the Dist. is above 90°.

=
add L=
D=

Hor.^{l} Par.^{x} — Propor.^{l} Log.^{m}
☉'s Altitude — Co Secant
Number D. — Sine

1.st Arc — Propor.^{l} Log.^{m}

° ′ ″

Hor.^{l} Par.^{x} — Propor.^{l} Log.^{m}
☽'s Altitude — Co Secant
Number D. — Tangent

2.^{d} Arc — Propor.^{l} Log.^{m}

C = — Add the Arcs if D. is above 90°.
D = — Add C to D if 1.st Arc is least & D (is under 90°.

E =
F = — Last Corr.^{n} add if D. is under 90.

P = — True Dist. of Centres.

° ′ ″ — ° ′ ″

Hours — D.° Hours
Hours — P

Diff. — Diff.
1.st Prop.^{l} Log.^{m} — 2.^{d} Prop.^{l} Log.^{m}
2.^{d} Prop.^{l} Log.^{m}

Diff.^{e} of Log.^{s} — in Prop.^{l} Log.^{s} H ′ ″
1.st Hours add

Time at Greenw.

° ′

Co. lat.
à Pole
Co. Alt. — Co. ar.
2) — Co. ar.

½ Sum — Sine
Rem.^{r} — Sine

2)

° ′

Arc — Co. Sine
16) 2 (— H ′ ″ à Noon

H ′ ″
Time at the Ship
Time at Greenw.

Ship's Longitude ° ′ or

The Co. ar. Sine, Tangent, &c. of Degrees when more than 90 is that of the Supp.^{t} to 180°. The Co. ar. is Co. Sec. less 10 in the Index. In this Formula, when Addition is not to be made subtraction must. For correct Time, at the Ship, see my New Epitome of Navigation.

S. Dunn delin.^{t}

Published according to Act of Parliament, Nov.^{r} 17.th 1777. by Samuel Dunn, Maiden Lane, Covent Garden, London.

A Formula for the LONGITUDE having the Ephemeris & Common Tables of Logarithms By S. Dunn Teacher of Mathematics LONDON.

☉ or ✱ ☽ I.[t] ☽ Alt I.[t] ☉ Alt. I.[t] Rough Time & H. Lat.

Nearest Limbs.	°	′	″
☉ or ✱ à ☽ Limbs obs.[d]			
☉ Semidiam.[r] p. 3			
☽ Semidiam.[r] p. 7			
Parts for ☽ Alt.			
Sum is D =			

☽ Altitude — Dip & Semid.[r] clear'd.

☽ Coalt — co.ar.

D — co.ar.

☉ or ✱ Coalt.

2)

½ Sum — Sine

Remain — Sine — 2)

Co. arch — Sine

2

M =

☽ Co. alt — Sine

☽ Hor. Par.[x] Log.

☽ Par.[x] Alt. Log.

☽ Refraction sub.

Difference Log.

M = — Co. sine

= A — Log.

Farthest Limb	°	′	″
✱ à ☽ Limb.			
☽ Semid.[r]			
Parts for ☽ Alt.			
Sum sub.			
Remain.[r] is D =			

☉ or ✱ Alt. — Dip & Semid.[r] clear'd.

☉ or ✱ Coalt — co.ar.

D — co.ar.

☽ Coalt.

2)

½ Sum — Sine

Remain. — Sine — 2)

Co. arch — Sine

2

S = — Co. sine

☉ Refraction

☉ Par.[x] in Alt. — add

Difference — Log.

B = — Log.

A = — sub. if M is under 90°.

B = — add if S is under 90°.

C = — is

D =

E =

Hours ° ′ ″

= first Hour & Distance in Ephem.[s]

= second ditto.

ditto

Diff. = — = — ″ Log. — sub.

=

E = — 3 · 4314 — add

Diff — = — Log. — add

Sum

° ′ = — Log.

Add — first Hours in Degrees

Time at Greenwich in Degrees.

° ′

Co. latitude — co.ar.

Polar dist. — co.ar.

Co. altitude

2)

½ Sum — Sine

Remain — Sine

Co. arch — Sine

2

Aft.[r] noon — Time at the Ship

Bef. noon

Long.[d]

For ☽ Altitude °	Parts ″	For ☽ Altitude °	Parts ″
10	2	40	10
15	4	50	12
20	6	60	14
30	8	80	16

For ☉ Altitude °	allow ☉ Par. in Alt. ″
30	7
40	6
50	5
60	4
70	3
75	2

N.B. 1.[st] Rough central Distance shews the rough Hour at Greenwich & thereby the ☉'s Declin.[n] is had Ephem. p. 2 (the ☉'s Semid.[r] is p. 3.) the ☽'s Semid.[r] & Hor. Par.[x] p. 7. 2.[d] Co. ar. is Cosecant less 10 in the Index. 3.[d] Co. ar. or Sine &c. of more than 90° is of the Remain.[r] to 180°. 4.[th] Refraction to be taken from the truest Tables. 5.[th] When you do not add subtract. 6.[th] Co. alt. sub-tracted from ½ Sum gives Remainder. Polar Dist. is Decl.[n]'s subtracted from 90° if Decl.[n] & Lat. alike, else added to 90°. 7.[th] If Time at Greenwich & at the Ship are both before or afternoon, their Difference is the Longitude; else it is what they are apart. 8.[th] Observe for Time at the Ship when ☉ is not near the Meridian. 9.[th] Reasons at large are in Astronomy p. 185 & Lon-gitude at Sea p. 90. 10.[th] Latitude is found at any Time of the Day by the common Logarithms, as published by the Author, which see.

S. Dunn inv.[t] & delin.[t]

Published according to Act of Parliament March 17.[th] 17[illegible] By Samuel Dunn Maiden Lane Covent Garden LONDON.

EXAMPLE V.

	°	′	″
Distance observed	110	22	5
Sun's Altitude	45	33	36
Moon's Altitude	19	43	6
Moon's Hor. Par.	0	57	19

Required the true Dist. of Centres?

1st. By Linear Tables.

Nº in Table I.			2.163
Co. ar. of Dist. observed			0.028
155″ Com. Log. Sum			2.191
41 in Table II.	°	′	″
196 Correction	0	3	16
Dist. observed	110	22	5
D =	110	25	21
1st Arc =	0	57	19
2d Arc =	0	7	11
C =	0	50	50
D =	110	25	21
E =	109	34	31
F =	0	0	1
P =	109	34	30

2d. By Sun & Moon's Angles.

	°	′	″
M =	19	38	
S =	27	56	
A =			2902
B =			44
C =	0	47	38
D =	110	22	5
E =	109	34	27
F =	0	0	1
P =	109	34	26

3d. By different Methods.

	°	′	″
1. By the Linear Tables	109	34	30
2. By Sun and Moon's Angles	109	34	26
3. By Lyons's whole Degrees	109	34	30
4. By Lyons altered	109	34	26

EXAMPLE VI.

	°	′	″
Distance observed	50	8	41
Star's Altitude	19	18	5
Moon's Altitude	55	56	5
Moon's Hor. Par.	1	0	5

Required the true Dist. of Centres?

1st. By Linear Tables.

Nº in Table I.			2.215
Co. ar. of Dist. observed			0.115
214″ Com. Log. Sum			2.330
91 in Table II.	°	′	″
123 Correction	0	2	3
Dist. observed	50	8	41
D =	50	10	44
1st Arc =	0	25	48
2d Arc =	0	41	29
C =	0	15	41
D =	50	10	44
E =	50	26	25
F =	0	0	5
P =	50	26	30

2d. By Sun & Moon's Angles.

	°	′	″
M =	117	48	
S =	31	42	
A =			924
B =			137
C =	0	17	41
D =	50	8	41
E =	50	26	22
F =	0	0	5
P =	50	26	27

3d. By different Methods.

	°	′	″
1. By the Linear Tables	50	26	30
2. By Sun and Moon's Angles	50	26	27
3. By Lyons's whole Degrees	50	26	29
4. By Ditto altered	50	26	29
5. By Dunthorne altered	50	26	28

EXAMPLE VII.

	°	'	"
" Distance observed	28	14	39"
Star's Altitude	20	11	4
Moon's Altitude	18	56	4
Moon's Hor. Par.	0	55	30

Required the true Dist. of Centres?

1st. By Linear Tables.

	°	'	"
No. in Table III.	0	0	30
Dist. observed	28	14	39
D =	28	15	9
1st Arc =	0	40	22
2d Arc =	0	33	26
C =	0	6	56
D =	28	15	9
E =	28	8	13
F =	0	0	44
P =	28	8	57

2d. By Sun & Moon's Angles.

	°	'	"
M =	82	24	
S =	87	22	
A =			395
B =			8
C =	0	6	27
D =	28	14	39
E =	28	8	12
F =	0	0	44
P =	28	8	56

3d. By different Methods.

	°	'	"
1. By the Linear Tables	28	8	57
2. By Sun and Moon's Angles	28	8	56
3. By Lyons's whole Degrees	28	8	56
4. By Ditto altered	28	8	57

EXAMPLE VIII.

	°	'	"
" Distance observed	59	25	34"
Sun's Altitude	59	12	5
Moon's Altitude	27	2	5
Moon's Hor. Par.	0	59	58

Required the true Dist. of Centres?

1st. By Linear Tables.

No. in Table I.	2.136
Co. ar. of Dist. observed	0.065
159" Com. Log. Sum	2.201

	°	'	"
65 in Table II.			
94 Correction	0	1	34
Dist. observed	59	25	34
D =	59	27	8
1st Arc =	0	59	48
2d Arc =	0	16	4
C =	0	43	44
D =	59	27	8
E =	58	43	24
F =	0	0	5
P =	58	43	29

2d. By Sun & Moon's Angles.

	°	'	"
M =	35	4	
S =	87	42	
A =			2533
B =			1
C =	0	42	12
D =	59	25	34
E =	58	43	22
F =	0	0	5
P =	58	43	27

3d. By different Methods.

	°	'	"
1. By the Linear Tables	58	43	29
2. By Sun and Moon's Angles	58	43	27
3. By Lyons's whole Degrees	58	43	26
4. By Ditto altered	58	43	29

EXAMPLE

EXAMPLE IX.

	°	′	″
" Distance observed	43	35	42"
Star's Altitude	11	18	6
Moon's Altitude	9	37	6
Moon's Hor. Par.	0	54	42

Required the true Dist. of Centres?

1st. By Linear Tables.

N° in Table I.	2.052
Co. ar. of Dist. observed	0.161
163″ Com. Log. Sum	2.213
118 in Table II.	

	°	′	″
45 Correction	0	0	45
Dist. observed	43	35	42
D =	43	36	27
1st Arc =	0	15	24
2d Arc =	0	9	32
C =	0	5	52
D =	43	36	27
E =	43	30	35
F =	0	0	26
P =	43	31	1

2d. By Sun & Moon's Angles.

	°	′	″
M =	83	43	
S =	87	50	
A =			319
B =			11
C =	0	5	8
D =	43	35	42
E =	43	30	34
F =	0	0	26
P =	43	31	0

3d. By different Methods.

	°	′	″
1. By the Linear Tables	43	31	1
2. By Sun and Moon's Angles	42	31	0
3. By Lyons's whole Degrees	43	31	1
4. By Astronomer Royal	43	31	2

EXAMPLE X.

	°	′	″
" Distance observed	29	24	46"
Star's Altitude	49	57	4
Moon's Altitude	64	19	4
Moon's Hor. Par.	0	57	8

Required the true Dist. of Centres?

1st. By Linear Tables.

	°	′	″
N° in Table III.	0	0	31
Dist. observed	29	24	46
D =	29	25	17
1st Arc =	1	44	50
2d Arc =	1	17	34
C =	0	27	16
D =	29	25	17
E =	28	58	1
F =	0	0	7
P =	28	58	8

2d. By Sun & Moon's Angles.

	°	′	″
M =	42	4	
S =	95	19	
A =			1602
B =			2
C =	0	26	44
D =	29	24	46
E =	28	58	2
F =	0	0	7
P =	28	58	9

3d. By different Methods.

	°	′	″
1. By the Linear Tables	28	58	8
2. By Sun and Moon's Angles	28	58	9
3. Ey Lyons's whole Degrees	28	58	9
4. By Witchell's Method	28	58	11

EXAMPLE XI.

	°	′	″
"Distance observed	62	23	59"
Star's Altitude	18	42	6
Moon's Altitude	47	42	6
Moon's Hor. Par.	0	57	6

Required the true Dist. of Centres.

1st. By Linear Tables.

N° in Table I.			2.188
Co. ar. of Dist. observed			0.052
174″ Com. Log. Sum			2.240
58 in Table II.	°	′	″
116 Correction	0	1	56
Dist. observed	62	23	59
D =	62	25	55
1st Arc =	0	20	36
2d Arc =	0	22	3
C =	0	1	27
D =	62	25	55
E =	62	27	22
F =	0	0	5
P =	62	27	27

2d. By Sun & Moon's Angles.

	°	′	″
M =	92	8	
S =	45	15	
A =			84
B =			116
C =	0	3	20
D =	62	23	59
E =	62	27	19
F =	0	0	5
P =	62	27	24

3d. By different Methods.

	°	′	″
1. By the Linear Tables	62	27	27
2. By Sun and Moon's Angles	62	27	24
3. By Lyons's whole Degrees	62	27	26
4. By Witchell's Method	62	27	27

EXAMPLE XII.

	°	′	″
"Distance observed	85	0	0"
Star's Altitude	5	0	5
Moon's Altitude	30	0	5
Moon's Hor. Par.	1	0	0

Required the true Dist. of Centres?

1st. By Linear Tables.

N° in Table I.			2.480
Co. ar. of Dist. observed			0.002
303″ Com. Log. Sum			2.482
9 in Table II.	°	′	″
294 Correction	0	4	54
Dist. observed	85	0	0
D =	85	4	54
1st Arc =	0	5	4
2d Arc =	0	2	34
C =	0	2	30
D =	85	4	54
E =	85	2	24
F =	0	0	2
P =	85	2	26

2d. By Sun & Moon's Angles.

	°	′	″
M =	87	6	
S =	60	12	
A =			153
B =			295
C =	0	2	22
D =	85	0	0
E =	85	2	22
F =	0	0	2
P =	85	2	24

3d. By different Methods.

	°	′	″
1. By the Linear Tables	85	2	26
2. By Sun and Moon's Angles	85	2	24
3. By Lyons's whole Degree	85	2	31
4. By Witchell's Method	85	2	27

EXAMPLE

EXAMPLE XIII.

	°	′	″
" Distance observed	38	22	17"
Star's Altitude	12	27	5
Moon's Altitude	20	9	4
Moon's Hor. Par.	0	57	24

Required the true Dist. of Centres?

1st. By Linear Tables.

Nº in Table I.	2.095		
Co. ar. of Dist. observed	0.207		
201″ Com. Log. Sum	2.302		
140 in Table II.	°	′	″
61 Correction	0	1	1
Dist. observed	38	22	17
D =	38	23	18
1st Arc =	0	19	49
2d Arc =	0	24	54
C =	0	5	5
D =	38	23	18
E =	38	28	23
F =	0	0	31
P =	38	28	54

2d. By Sun & Moon's Angles.

	°	′	″
M =	95	22	
S =	73	12	
A =			288
B =			73
C =	0	6	1
D =	38	22	17
E =	38	28	18
F =	0	0	31
P =	38	28	49

3d. By different Methods.

	°	′	″
1. By the Linear Tables	38	28	54
2. By Sun and Moon's Angles	38	28	49
3. By Lyons's whole Degrees	38	28	59
4. By Cambridge Tables	38	28	56

EXAMPLE XIV.

	°	′	″
" Distance observed	45	40	14"
Star's Altitude	15	54	4
Moon's Altitude	21	26	4
Moon's Hor. Par.	0	56	30

Required the true Dist. of Centres?

1st. By Linear Tables.

Nº in Table I.	2.074		
Co. ar. of Dist. observed	0.146		
166″ Com. Log. Sum	2.220		
109 in Table II.	°	′	″
57 Correction	0	0	57
Dist. observed	45	40	14
D =	45	41	11
1st Arc =	0	21	35
2d Arc =	0	20	27
C =	0	1	28
D =	45	41	11
E =	45	39	43
F =	0	0	23
P =	45	40	6

2d. By Sun & Moon's Angles.

	°	′	″
M =	88	25	
S =	75	22	
A =			83
B =			50
C =	0	0	33
D =	45	40	14
E =	45	39	41
F =	0	0	23
P =	45	40	4

3d. By different Methods.

	°	′	″
1. By the Linear Tables	45	40	6
2. By Sun and Moon's Angles	45	40	4
3. By Lyons's whole Degrees	45	40	1
4. By Cambridge Tables	45	40	7

EXAMPLE XV.

	°	′	″
" Distance observed	65	27	30"
Star's Altitude	78	18	6
Moon's Altitude	15	21	6
Moon's Hor. Par.	1	0	25

Required the true Dist. of Centres?

1st. By Linear Tables.

Nº in Table I.			2.349
Co. ar. of Dist. observed			0.041
246″ Com. Log. Sum			2.390
50 in Table II.	°	′	″
196 Correction	0	3	16
Dist. observed	65	27	30
D =	65	30	46
1st Arc =	1	5	1
2d Arc =	0	7	11
C =	0	57	50
D =	65	30	46
E =	64	32	56
F =	0	0	1
P =	64	32	57

2d. By Sun & Moon's Angles.

	°	′	″
M =	7	46	
S =	140	24	
A =			3259
B =			9
C =	0	54	28
D =	65	27	30
E =	64	33	2
F =	0	0	1
P =	64	33	3

3d. By different Methods.

	°	′	″
1. By the Linear Tables	64	32	57
2. By Sun and Moon's Angles	64	33	3
3. By Lyons's whole Degree	64	32	59
4. By Cambridge Tables	64	32	59

EXAMPLE XVI.

	°	′	″
" Distance observed	49	17	21"
Star's Altitude	27	15	5
Moon's Altitude	43	20	5
Moon's Hor. Par.	0	58	50

Required the true Dist. of Centres?

1st. By Linear Tables.

Nº in Table I.			2.090
Co. ar. of Dist. observed			0.120
162″ Com. Log. Sum			2.210
95 in Table II.	°	′	″
67 Correction	0	1	7
Dist. observed	49	17	21
D =	49	18	28
1st Arc =	0	35	30
2d Arc =	0	34	44
C =	0	0	46
D =	49	18	28
E =	49	17	42
F =	0	0	13
P =	49	17	55

2d. By Sun & Moon's Angles.

	°	′	″
M =	88	57	
S =	54	53	
A =			46
B =			64
C =	0	0	18
D =	49	17	21
E =	49	17	39
F =	0	0	13
P =	49	17	52

3d. By different Methods.

	°	′	″
1. By the Linear Tables	49	17	55
2. By Sun and Moon's Angles	49	17	52
3. By Lyon's whole Degrees	49	17	54
4. By Cambridge Tables	49	17	54

EXAMPLE XVII.

	°	′	″
" Distance observed	35	29	45"
Star's Altitude	17	40	5
Moon's Altitude	20	34	5
Moon's Hor. Par.	0	56	24

Required the true Dist. of Centres?

1st. By Linear Tables.

	°	′	″
Nº in Table III.	0	0	37
Dist. observed	35	29	45
D =	35	30	22
1st Arc =	0	29	24
2d Arc =	0	27	44
C =	0	1	40
D =	35	30	22
E =	35	28	42
F =	0	0	33
P =	35	29	15

2d. By Sun & Moon's Angles.

	°	′	″
M =	88	9	
S =	79	8	
A =			97
B =			33
C =	0	1	4
D =	35	29	45
E =	35	28	41
F =	0	0	33
P =	35	29	14

3d. By different Methods.

	°	′	″
1. By the Linear Tables	35	29	15
2. By Sun and Moon's Angles	35	29	14
3. By Lyons's whole Degrees	35	29	14
4. By Cambridge Tables	35	29	20

EXAMPLE XVIII.

	°	′	″
" Distance observed	102	30	0"
Star's Altitude	15	25	5
Moon's Altitude	27	30	5
Moon's Hor. Par.	0	57	3

Required the true Dist. of Centres?

1st. By Linear Tables.

Nº in Table I.	2.112
Co. ar. of Dist. observed	0.010
133″ Com. Log. Sum	2.122

	°	′	″
24 in Table II.			
157 Correction	0	2	37
Dist. observed	102	30	0
D =	102	32	37
1st Arc =	0	15	29
2d Arc =	0	5	51
C =	0	21	20
D =	102	32	37
E =	102	11	17
F =	0	0	5
P =	102	11	12

2d. By Sun & Moon's Angles.

	°	′	″
M =	65	0	
S =	56	30	
A =			1237
B =			113
C =	0	18	44
D =	102	30	0
E =	102	11	16
F =	0	0	5
P =	102	11	11

3d. By different Methods.

	°	′	″
1. By the Linear Tables	102	11	12
2. By Sun and Moon's Angles	102	11	11
3. By Lyons's whole Degrees	102	11	15
4. By Ditto himself	102	11	11
5. By 12 Case Method	102	10	54

EXAMPLE XIX.

	°	′	″
"Distance observed	33	15	0"
Star's Altitude	48	20	5
Moon's Altitude	64	30	5
Moon's Hor. Par.	0	55	29

Required the true Dist. of Centres?

1st. By Linear Tables.

	°	′	″
No. in Table III.	0	0	35
Dist. observed	33	15	0
D =	33	15	35
1st Arc =	1	15	33
2d Arc =	1	16	21
C =	0	0	48
D =	33	15	35
E =	33	16	23
F =	0	0	6
P =	33	16	29

2d. By Sun & Moon's Angles.

	°	′	″
M =	91	58	
S =	40	25	
A =			48
B =			38
C =	0	1	26
D =	33	15	0
E =	33	16	26
F =	0	0	6
P =	33	16	32

3d. By different Methods.

	°	′	″
1. By the Linear Tables	33	16	29
2. By Sun and Moon's Angles	33	16	32
3. By Lyons's whole Degrees	33	16	29
4. By Ditto himself	33	16	29

EXAMPLE XX.

	°	′	″
"Distance observed	56	17	44"
Star's Altitude	53	13	8
Moon's Altitude	64	38	4
Moon's Hor. Par:	1	1	9

Required the true Dist. of Centres?

1st. By Linear Tables.

	°	′	″
No. in Table III.	0	1	1
Dist. observed	56	17	44
D =	56	18	45
1st Arc =	0	58	50
2d Arc =	0	36	49
C =	0	22	1
D =	56	18	45
E =	55	56	44
F =	0	0	0
P =	55	56	44

2d. By Sun & Moon's Angles.

	°	′	″
M =	32	16	
S =	21	50	
A =			1406
B =			40
C =	0	21	6
D =	56	17	44
E =	55	56	38
F =	0	0	0
P =	55	56	38

3d. By different Methods.

	°	′	″
1. By the Linear Tables	55	56	44
2. By Sun and Moon's Angles	55	56	38
3. Ey Lyons's whole Degrees	55	56	45
4. By Ditto himself -	55	56	46
5. By 12 Case Method	55	56	50

EXAMPLE

EXAMPLE XXI.

	°	'	"
" Distance observed	113	19	26"
Sun's Altitude	5	1	5
Moon's Altitude	29	38	5
Moon's Hor. Par.	0	56	29

Required the true Dist. of Centres.

1st. By Linear Tables.

N° in Table I.			2.478
Co. ar. of Dist. observed			0.037
328″ Com. Log. Sum			2.515
48 in Table II.	°	'	"
376 Correction	0	6	16
Dist. observed	113	19	26
D =	113	25	42
1st Arc =	0	5	13
2d Arc =	0	12	6
C =	0	17	19
D =	113	25	42
E =	113	8	23
F =	0	0	9
P =	113	8	14

2d. By Sun & Moon's Angles.

	°	'	"
M =	69	13	
S =	54	39	
A =			1010
B =			339
C =	0	11	11
D =	113	19	26
E =	113	8	15
F =	0	0	9
P =	113	8	6

3d. By different Methods.

	°	'	"
1. By the Linear Tables	113	8	14
2. By Sun and Moon's Angles	113	8	6
3. By Lyons's whole Degrees	113	8	19
4. By Witchell's Method	113	8	12

EXAMPLE XXII.

	°	'	"
" Distance observed	101	46	43"
Sun's Altitude	56	16	0
Moon's Altitude	17	47	0
Moon's Hor. Par.	0	56	40

Required the true Dist. of Centres?

1st. By Linear Tables.

N° in Table I.			2.240
Co. ar. of Dist. observed			0.009
177″ Com. Log. Sum			2.249
22 in Table II.	°	'	"
199 Correction	0	3	19
Dist. observed	85	0	0
D =	101	46	43
1st Arc =	0	48	9
2d Arc =	0	3	37
C =	0	51	46
D =	101	50	2
E =	100	58	16
F =	0	0	1
P =	100	58	15

2d. By Sun & Moon's Angles.

	°	'	"
M =	16	22	
S =	35	6	
A =			2936
B =			28
C =	0	48	28
D =	101	46	43
E =	100	58	15
F =	0	0	1
P =	100	58	14

3d. By different Methods.

	°	'	"
1. By the Linear Tables	100	58	15
2. By Sun and Moon's Angles	100	58	14
3. By Lyons's whole Degree	100	58	17
4. By Witchell's Method	100	58	0

SECTION

SECTION XVIII.

Of the TIME at GREENWICH and at the SHIP.

The Time at Greenwich and at the Ship, may be expreſſed either in Hours, Minutes and Seconds, or in Degrees, Minutes and Seconds, allowing Fifteen Degrees to an Hour of Time; but it will be moſt eaſy and expeditious to uſe the latter of theſe two methods; nevertheleſs, either of them may be uſed, as it may be thought moſt adviſeable.

The lowermoſt Line in the table of Proper Logarithms, increaſes by Fifteen Minutes to Forty-five Degrees. The uppermoſt Line increaſes to Three Degrees, which may alſo be called Three Hours of Time.

When the laſt Difference of Proper Logarithms is found; if Hours are to expreſs the Time at Greenwich, the Degrees and Minutes at Top are Hours and Minutes, and the Seconds are in the ſide of the Table; to theſe add the firſt Hours, and the Time at Greenwich is had in Time.

If the Time at Greenwich, is to be expreſſed in Degrees, a Fourth part of the Seconds in the Side are Minutes to be added to the Degrees and Minutes in the lowermoſt line of the Table, and this added to the firſt Hours in Degrees, gives the Time at Greenwich in Degrees and Minutes.

By the ſame Method, the Time at the Ship, either paſt Noon or ſhort of Noon, is found in Degrees and Minutes; and theſe compared with the Time at Greenwich, gives the Longitude.

This eaſy Method of avoiding the ſeveral Reductions into Time, was firſt pointed out in the *Theory and Practice of Longitude* and Formulæ therewith; and is unexceptionable, as the Time at the Ship is to be applied to that at Greenwich, in the ſame manner whilſt it is in Degrees, as it would be if it was in Time.

When a Watch is ſet for ſhewing the Time at the Ship or rather at the Meridian where Obſervations have been made for its adjuſtment; the Reductions to Time are to be made in the uſual manner.

The Expreſſion for Longitude is and ever will be in Degrees and not Time, becauſe the Charts are inſtituted on that Plan, and the whole Syſtem of Aſtronomical Calculations and Tables. It would therefore be, not only beſt for the Eaſe of the Longitude Computor, but moſt exact (if he muſt uſe a Watch for ſhewing Time at the Ship) to get one that ſhews Degrees and Minutes of the Equator, as ſuch an one would be alſo more readily applied to the other Methods of finding Longitude at Sea, and other parts of Practical Aſtronomy; but in ſuch caſe, the Equation Tables and all others muſt be regulated accordingly.

EXAMPLE

EXAMPLE I.

H		°	′	″		
3	=	73	1	27		
6	=	74	28	50		
		1	27	23		
Proper Log.					=	0.3139
3	=	73	1	27		
P	=	74	11	58		
		1	10	31		
Proper Log.					=	0.4070
		36	19		=	0.0931
		45	0			
Time		81	19	Gr. P. M.		
Co-lat.		55	43		=	0.0829
Pol. dist.		84	12		=	0.0022
Co. alt.		70	38			
		210	33			
		105	16		=	9.9844
		34	38		=	9.7546
						19.8241
		35	15		=	9.91205
Time		70	30	Ship P. M.		
Longitude		10	49	W.		

EXAMPLE II.

H		°	′	″		
3	=	108	5	58		
6	=	109	37	16		
		1	31	18		
Proper Log.					=	0.2948
3	=	108	5	58		
P	=	109	34	26		
		1	28	28		
Proper Log.					=	0.3085
		43	36		=	0.0137
		45				
Time		88	36	Gr. P. M.		
Co-lat.		56	23		=	0.0795
Pol. dist.		67	25		=	0.0346
Co-alt.		44	28			
		168	16			
		84	8		=	9.9977
		39	40		=	9.8050
						19.9168
		24	40½		=	9.9584
Time		49	21	Ship P. M.		
Longitude		39	59	W.		

EXAMPLE III.

H		°	′	″		
6	=	93	57	36		
9	=	95	32	11		
		1	34	35		
Proper Log.					=	0.2795
6	=	93	57	36		
P	=	95	18	6		
		1	20	30		
Proper Log.					=	0.3495
		38	18		=	0.0700
		90	0			
Time		128	18	Gr. P. M.		
Co-lat.		69	30		=	0.0284
Pol. dist.		100	46		=	0.0077
Co-alt.		50	19			
		220	35			
		110	17		=	9.9722
		59	58		=	9.9374
						19.9457
		20	3		=	9.97285
Time		40	6	Ship P. M.		
Longitude		88	12	W.		

During ten years till 1777 it was thought absolutely necessary to have a good Watch for shewing Time at the Ship, but this was exploded by my Formula for that purpose, and more particularly the year following in the Theory and Practice of Longitude at Sea; because the Time at the Ship is easily determined from the Latitude and the Cotemporary Observations. Whereas, 1st. The Watch may not be set right. 2d. It may not go right. 3d. The Course may not be truly known. 4th. The Variation may not be known. 5th. The Distance may not be truly measured. When the Time so carried is great, and several of these Errors are of the same kind, the amount may be considerable, and therefore it behoves every person practising this Method to avoid as much as possible, these Errors.

SECTION

SECTION XIX.

Of the apparent Places, Diurnal Motions and Periodic Revolutions of the Sun, Moon, Primary Planets and Fixed Stars.

1. The Sun is always apparently in the Ecliptic Line, and therefore hath Right Ascension, Declination and Longitude, but no Latitude.

2. The Moon is always apparently near the Ecliptic, sometimes a few degrees north or south thereof, at other times in it; and therefore may have Right Ascension and Declination, Longitude and Latitude.

3. Mercury and Venus; Mars, Jupiter and Saturn, are always apparently near the Ecliptic, and therefore may have Right Ascension and Declination, Longitude and Latitude.

4. Some of the Fixed Stars are near and others remote from the Ecliptic; therefore, they may have Right Ascension and Declination, Longitude and Latitude.

Of the Diurnal Motions.

5. The Sun apparently moves round the Earth, in the Interval of Time called a Solar Day.

6. The Moon apparently moves round the Earth at a Medium, in an Interval which is 52 Minutes longer than a Solar Day.

7. The Primary Planets may apparently move round the Earth, either in a Solar Day or a little longer or shorter Interval, according to their Places in the Heavens.

8. The fixed Stars apparently move round the Earth in a shorter Interval of Time than the Sun, by almost a Degree of the Equator or 3′.57″ of Time.

Of the Periodic Revolutions.

9. The Sun apparently moves round the Ecliptic in the Interval of a Solar Year, or 365 Days 5 Hours 49 Minutes.

10. The Moon apparently moves round the Ecliptic, or rather near it, in 27 Days 7 hours 43 Minutes; but it is 29 Days and near 13 Hours, by the Time she comes to the same apparent Longitude with the Sun.

11. The Primary Planets are near the Sun, as follows; namely, Mercury in 58 Days; Venus in 292 Days; Mars in 780 Days; Jupiter in 398 Days; Saturn in 378 Days. Therefore, in these Intervals, they come nearly to their like apparent Distances from the Sun.

12. The

12. The Fixed Stars apparently move round the Poles of the Ecliptic in an Interval of 25920 Years.

SECTION XX.

Of the Places of the Zodiacal Stars.

1. The Zodiac is a Space of near 17 Degrees in Breadth, extending round the Heavens, and divided in the Middle by the Ecliptic Line.

2. The Fixed Stars within the Bounds of the Zodiac are called the Zodiacal Stars. Thoſe of the firſt Magnitude either within this Limit, or not far north or ſouth from it, are uſed in finding the Longitude at Sea in the Night, in the Lunar Method.

3. The Zodiacal Stars of greater Appearance within the Zodiac, are

1ſt. ALDEBARAN; a Red Star having many ſmall Stars round it, and the Seven Stars to its northweſt.

2d. POLLUX about 45° eaſtward from Aldebaran, having Caſtor a Star of the ſame Magnitude, north weſtwardly from it.

3d. REGULUS; a Red Star, about 37° ſoutheaſtward from Pollux, known by being ſouthermoſt of four Stars in a Zigzag line, north and ſouth.

4th. Spica; a ſmall white ſparkling Star about 54° ſoutheaſtward from Regulus.

5th. ANTARES; a large Red Star about 46° ſoutheaſtward from Spica, having ſeveral ſmall Stars weſtward of it like a Bow.

6th. β CAPRICORNI; is a ſmall Star about 56° eaſtward from Antares, and known by another ſmall Star near it northward.

4. The Stars without the Zodiac that are uſed in the Lunar Method, are introduced to ſupply the Defect of β Capricorni; namely,

7th. α PEGASI. 8th. α ARIETIS. 9th. α AQUILÆ, a white ſparkling Star about 25° northward from β Capricorni, having a ſmall Star near it northward. 10th. FOMALHAUT, a large Star about 45° ſouth from α Pegaſi.

5. The Zodiacal Stars that can moſt eaſily be found; are, Aldebaran, Pollux, Regulus, Spica, Antares; and out of the Zodiac, Aquilæ and Fomalhaut; the other three, α Pegaſi, α Arietis and β Capricorni, are eaſily found by the Chart of Zodiacal Stars.

SECTION XXI.

Of the Poſitions which the Ecliptic and Zodiac may have, at different Times and Places.

Whilſt the Celeſtial Bodies are apparently moving round the Earth's Axis from Eaſt toward Weſt, and the Circles of the Celeſtial

lestial Sphere with them; the Ecliptic will take various Positions to the Horizon, during the Interval of every 24 Hours of Time.

The Moon and Zodiacal Stars being near the Ecliptic, their Positions to the Horizon, and to one another, must undergo the same Changes as the Circles of the Sphere, in which they are apparently situated.

1. In Latitude 66° 32′ N. when the Sun enters Capricorn; at Noon the Ecliptic and Horizon coincide. In the same Latitude South, when the Sun enters Cancer; at Noon the Ecliptic is in the Horizon.

2. At all other Places and Times; one Half of the Ecliptic is above the Horizon and the other half under it.

3. The Point of the Ecliptic in which the Sun apparently is, comes to the Meridian, likewise to the Horizon at Sun-rising and Sun-setting, with the Sun.

4. That Half of the Ecliptic which is above the Horizon, is changing its Position continually; sometimes it is perpendicular to the Horizon at some places, and at other times it is inclining to it northward or southward.

5. To Observers between the Tropics (that is, between 23° 28′ North and South Latitudes) the Ecliptic is Perpendicular to the the Horizon, once eastward and once westward in the Space of every 24 Hours.

6. The Fixed Stars without the Zodiac, become perpendicularly over or under the Moon frequently, according to their respective Places in the Heavens.

SECTION XXII.

Of the Cusps and Phases of the Moon, with their Positions to the Sun and Zodiacal Stars.

In order to understand how the Moon's Cusps or Phases are formed, it is necessary to know how she is illuminated by the Sun, and how she gets into North or South Latitude by crossing the Ecliptic under an Angle of 5° 18′ nearly.

Could the Moon be always accurately in the Ecliptic Line, the Line joining her Cusps, would be accurately at Right Angles to the Ecliptic; but as that cannot be, that Angle becomes varied according to her Latitude and Distance from the Sun.

This Method of finding the Zodiacal Stars by their Positions to the Moon and the Line joining her Cusps, is fully treated of in the *Theory and Practice of Longitude at Sea*, and the Use of the Chart of Zodiacal Stars.

Page 4. Ex. I. for 16″ read 16′
Page 9. Ex. I. for 24 feet read 32½ feet.
Page 9. Ex. II. for 140 feet read 25½ feet.
P. 10. line 2. for Table read Tables.
P. 13. line 23. for Log. read Degrees.
P. 15. line 18. for Sun read Star.

THE END.